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SESSION 1991–92

1st REPORT

SELECT COMMITTEE ON
SCIENCE AND TECHNOLOGY

SYSTEMATIC BIOLOGY
RESEARCH

VOLUME I—REPORT

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Written Evidence

Oral Evidence, 26 March 1991

Name of Lord

Written Evidence, *Printed pursuant to the Order of the House of Lords of 17th December 1991*

Oral Evidence, 16 April 1991

Overseas Development Administration

Written Evidence

Oral Evidence, 16 April 1991

Department of Education and Science

Written Evidence

Oral Evidence, 22 April 1991

Agriculture and Food Research Council

Written Evidence

Oral Evidence, 23 April 1991

Ministry of Agriculture, Fisheries and Food

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FIRST REPORT

17 DECEMBER 1991

By the Select Committee appointed to consider Science and Technology.

ORDERED TO REPORT:

SYSTEMATIC BIOLOGY RESEARCH

CHAPTER 1 INTRODUCTION

1.1 Systematic biology is the science of naming and classifying all organisms and of investigating the relationships between them. Variation is all-pervading in living things and the documentation and explanation of this variation is the business of systematic biology. But only a small fraction of the range of living things has been described and so the task is potentially enormous.

1.2 Not only is systematic biology a science in its own right; it is an essential tool in many forms of applied biological science. It is, for example, fundamental to one of the most challenging environmental issues of the day—biodiversity and its conservation.

1.3 The United Kingdom has traditionally been a leader in systematic biology research. Our natural history collections—like those at the Natural History Museum and the Royal Botanic Gardens Kew—on which so much of that research depends, are as fine as any in the world.

1.4 But, it is alleged, systematic biology no longer fits in comfortably with some of the more recent developments in biological science and the institutional framework in which science is carried out in the United Kingdom today.

- many of the institutions which house the collections and which are publicly funded are under financial pressures which inevitably affect the curation of the collections and the research that is carried out;
- the research councils who fund most of the United Kingdom's basic research have been reluctant to give grants for much of systematic biology which, they consider, offers less scope for originality; and
- at the universities the expansion of other areas of biological science has all but displaced systematic biology.

1.5 The Select Committee's initial attention was drawn to the subject late in 1990 by rather more immediate changes at the Natural History Museum, which in its Corporate Plan for 1991—95 had attempted to come to grips with the mounting financial distress of that institution. The staff cuts and the changes in research and curation policy which this entailed attracted widespread comment. The Royal Society received some 800 letters registering unease, from scientists all over the world.

1.6 These events, taken in the context of the allegations of a longer term attrition, led us to conduct an inquiry "to consider systematic biology research in the United Kingdom"¹. Our principal findings and recommendations are as follows.

1.7 Systematic biology research is not only of central importance to evolutionary theory but provides an essential framework to most other branches of biological science. Its benefits to mankind both in economic and human terms can be immeasurable. The quality of the systematics collections and the expertise of our systematists also places the United Kingdom in a unique position to contribute a firm scientific base to the current world drive to conserve biological diversity. Systematics research and curation of the collections on which it depends should therefore be maintained in good order.

1.8 Ultimately, and properly in our view, public funding of one sort or another bears the brunt of expenditure on systematic biology research. But public expenditure policy has meant that core funding of the major institutions has not been maintained in real terms and this has affected both the quality of curation and the amount of research performed. The criteria of originality applied by the research councils has meant that applications for support for many kinds of traditional systematic research have gone unfunded. And universities' own research facilities, on which systematists have relied, are themselves under pressure.

¹ The membership of the Sub-Committee which conducted the inquiry is set out in Appendix 1. The Committee met 18 times, heard 24 witnesses or sets of witnesses, and received 153 pieces of written evidence. This evidence is printed in companion volumes to this report, as follows: Written Evidence (to 21 May 1991) in Session 1990—91, HL Paper 41; Oral Evidence and Further Written Evidence (since 21 May 1991), in Session 1991—92, HL Paper 22-II.

1.9 As an academic subject in the institutes of higher education systematic biology has been widely displaced by newer areas of biological science and the increasing average age of systematists in the faculties is such as to render them almost an endangered species in themselves!

1.10 In our view these circumstances have all conspired to place systematic biology—the research itself, the curation of the collections, and its position at the universities—at a risk which the nation can ill afford and which reflects poorly upon the traditional, peer review, mechanisms for the funding of science today.

1.11 Our principal recommendations are that:

- in future core funding for research and curation of the collections in the major systematics institutions should be maintained in real terms;
- ABRC should establish a special fund for five years of £1m a year for systematic biology research;
- OAL should set up a rolling programme of up to £0.5m a year to assist systematics collections outside the grant-in-aided institutions;
- a new forum of systematics institutions should be established to rationalise holdings and expertise; and
- ABRC should assess the need for trained systematists and fund MSc courses in line with those requirements.

1.12 Taken together with our other recommendations we hope that these modest measures will give systematic biology research a much needed stimulus, after which we expect the subject to take its place with other branches of science.

CHAPTER 2 WHAT IS SYSTEMATIC BIOLOGY

A short definition

2.1 Systematic biology is the science of naming and classifying all organisms both living and extinct, and of investigating the relationships between them. In other words, it puts organisms into a system.

2.2 This process of nomenclature and classification is also called taxonomy. The procedure for naming all organisms is laid down in a set of internationally agreed rules. The name is called the “binomial” because it is in two parts, one of which represents the genus and one the species. Classification is meant to reflect organisms’ evolutionary history (its phylogeny), and can never be absolute because there is always scope for some diversity of interpretation.

2.3 Nevertheless, for most groups systematics provides science with an orderly system to which all living organisms can be referred, and records of them kept, in an internationally recognised format. This gives a framework of reference within which information may be readily and unambiguously exchanged between scientists from different disciplines and different parts of the world.

2.4 As witnesses pointed out to us, systematic biology is probably the area of the biological sciences that most clearly distinguishes those sciences from the physical sciences. Variation is all-pervading in living systems and the documentation, evaluation and explanation of the variation shown by living things is the business of systematic biology (Linnaean Society p.133; Systematics Association p.186; Mayr p.141).

2.5 Classifications should be based on as wide a range of evidence as possible concerning the nature and function of organisms, from their external and internal structural features, through their behaviour, distribution, and biochemical attributes. Their genetic characteristics (including the forms and number of their chromosomes) and increasingly in contemporary work, the makeup of their genetic material, their DNA, at a molecular level (DNA sequencing) also contribute most significantly to our understanding of their evolutionary relationships.

2.6 A classification based on the widest possible information will also have predictive value—the placement of a new species within the information framework will give an indication of the likely attributes in areas beyond those used in so placing it.

“Systematics” and “taxonomy”

2.7 Systematic biology embraces the science of taxonomy and the two terms were used synonymously throughout most of the evidence we received. Some witnesses sought to represent systematic biology as the broader discipline. Thus RBG Edinburgh wrote that systematics “is the

scientific study of the kinds and diversity of organisms and of any and all relations between them" (G G Simpson [1961] "Principles of Animal Taxonomy". Columbia University Press, p.7). It includes taxonomy, which is the naming and classification of all kinds of organisms ... "(RBG Edinburgh p.104). The Royal Society made a similar distinction in that "Systematic biology builds on taxonomy (the systematic giving of names to specimens) to investigate relationships between organisms" (Royal Society p.111). For the purposes of this report however we do not make such a rigorous distinction between the two.

The character of research

2.8 Systematic research is carried out at three levels, but most would agree that the boundaries between them are not sharp¹.

2.9 Descriptive taxonomy (so-called "alpha taxonomy", or "classical taxonomy") is the base level of systematic biology, involving the first description of new species. This will normally have originated in material probably from quite a limited area, and the description and illustration of specimens. The preservation of the material on which such descriptive biology is done (pressed plant specimens, or animals preserved in fixative for example) is an important feature of such work. "Type specimens", on which species names have been based, are regarded by systematists as particularly important as they can resolve any subsequent dispute over how the name was originally applied by its author.

2.10 Revisionary taxonomy, at various levels of sophistication ("beta-taxonomy"), may involve a wide range of techniques of observation, and a wider range of material to give a more comprehensive basis of description and taxonomic arrangement than "alpha taxonomy". Such work might, for example, produce monographs reviewing all the members of a genus or a family from the whole of its geographic range.

2.11 Interpretative taxonomy ("gamma-taxonomy") involves a fuller exploration of the basis of relationship, often with a high level of experimental work or field observation. For example, investigating the genetic diversity within the range of a species, or the biochemical constituents of a group of closely related plants, or a study of systematic features shown only by certain stages in the life cycle of a group of organisms. Frequently this involves extensive investigation of a wide range of living specimens, with an experimental approach: perhaps breeding living organisms and studying the genetic makeup of the progeny; or exploring the immunological affinity between organisms; or using other techniques now available to biologists in the field and the laboratory, to develop new insights into relationships between organisms. Molecular biology has now brought the further possibility of studying the genetic makeup of organisms at the molecular level—obtaining the sequence of bases which characterise part of the DNA of individual organisms. This gives a unique and highly significant way of plotting and analysing the degree of relationship between individual organisms and between major groups. In some cases this technique can even be applied to the remains of extinct organisms millions of years old. Much of the best systematic research is a combination of alpha, beta and gamma.

How "original" is the research?

2.12 Evidence presented to the committee shows a wide range of views as to what constitutes "research" in the field of systematic biology. Some would regard "alpha taxonomy" as outlined above as a rather mundane activity which has been compared to stamp collecting, and not one representing the kind of intellectual challenge that would qualify it as research at all. On this view, "research" begins only at the level of gamma taxonomy, where there is some element of inquiry, and an application of experimental techniques or novel approaches. However, many systematists, especially in the Natural History Museum (NHM), in CAB International² (CABI), and in many museums and systematic institutes would regard primary "alpha" taxonomic work as the very heart of systematic biology research. It is certainly essential for the study and documentation of biological diversity as we shall see in chapter 3.

2.13 These equivocal attitudes to alpha taxonomy doubtless stem from the elevation of scientific experimentation in modern scientific thinking, while in systematics much work inevitably relies on the untested opinion of other specialists. These attitudes have financial consequences for the subject. As we shall see in chapter 5 funding bodies will rarely support research proposals consisting

¹ These categories were set out in *Taxonomy in Britain*, ABRC, 1977, p.3.

² Formerly the Commonwealth Agricultural Bureau.

simply of alpha taxonomic study when they are competing with proposals which are perceived to be more innovative.

2.14 A good deal of systematic research in institutes and in some universities is involved in refining various aspects of gamma taxonomy. Some of this type of work is of a fairly hypothetical nature—for example, using DNA sequences, or analysis of a range of evidence to try to establish the path of evolution of the major taxonomic groupings. While research of this kind is of great theoretical interest to biologists, it has little obvious practical application. In other types of work, new methods such as biochemical screening, the development of computer software (“computerised keys”) which accelerate the identification of unknown organisms, and the application of image analysis to recognition problems, all hold promise of important applications in the applied field.

2.15 An element of systematic research is also involved in the many identification services which analyse biological material. Thus, for example, identification services within the broad fields of medicine (pathology), agriculture and horticulture (diseases of crops and animals, pests of plants and stored crop products) all involve the science of systematics of the causal organisms. The best practitioners of such services may be those who are also engaged in research in those fields. On the other hand, much of the routine identification will be carried out by scientists at a less highly qualified level, using manuals, collections and computer facilities which are themselves the products of systematic research.

2.16 Systematic research is frequently an aspect of, but probably not the driving force behind, much developmental and molecular biology. Professor Blundell’s work on insulin derived from relatives of the guinea pig (*hystricomorphs*) resulted in a rearrangement of the evolutionary (phylogenetic) relationships of these animals (AFRC QQ 212—215). That kind of discovery, we were told, was “occurring again and again” in universities and institutes.

Curation and its role in research

2.17 For all levels of systematic research, reference collections of reliably identified specimens, either living, or in a well-preserved state, are of fundamental importance. This is true whether the subject is a bacterial pathogen, a weed in agriculture or an insect pest of stored food. For much routine identification, descriptions and illustrations are adequate, but even then access to an extensive collection is desirable for ultimate confirmation of identity.

2.18 The curation of such collections involves a number of basic activities:

- Ensuring the long-term physical and biological well-being of the specimens in the collection. If this is a living collection, of say microorganisms, this will involve laboratory skills of a high order to maintain the cultures in a viable state. For non-living collections, their preservation and conservation involves different skills and itself requires some research to maintain requisite standards.
- Maintaining the labelling and identity of the specimens in pace with progress in contemporary research on the group. This of course involves following current research, perhaps published in other parts of the world.
- Maintaining a physical arrangement, and appropriate accessibility, consistent with the systematic attribution.
- Making value judgments concerning the status and nomenclature of specimens and their scientific quality, relevant to a policy of lending material to other scientists, perhaps in other parts of the world. Lending is very common.

2.19 This curatorial work is seen by most biological systematists as lying at one end of a spectrum of biological systematic research. For them, curation is an essential element underlying other systematic work and can be carried out adequately only if the curator is engaged personally in research on some part of his collection, thereby maintaining contact with research workers

elsewhere in the world. Others would maintain that such curatorial work is rather pedestrian, and can well be left to "collection managers", so freeing more experienced systematists to concentrate on primary research on the group of organisms in question. Witnesses are divided as to the extent to which research is an essential accompaniment to the curating process, as we shall see in chapter 6.

Research requirements

2.20 The requirements for basic taxonomic research (at both alpha and some beta-level work) are relatively straightforward. They consist of well-curated collections, relevant to the research being undertaken, access to library facilities appropriate to the groups and geographical areas involved, and laboratory facilities appropriate to the level of sophistication required. Much of the core taxonomic work on the bulk of the presently-known insects and flowering plants was carried out with no more sophisticated equipment than a dissecting microscope because traditional systematists used primarily structural (morphological) features of the organisms under study, as most early systematic research was done on dead preserved specimens in museums and other institutes.

2.21 But modern systematic work has greatly extended the scope of study, and with it the range of facilities needed. Systematic biology is above all a multidisciplinary field so that any new technique that can be used for comparative studies of organisms may potentially provide new and significant taxonomic data. Many witnesses drew attention to the newer biochemical sources of data for systematic biology, from protein gel electrophoresis to DNA sequencing and other new methods of molecular biology (Clarke p.52; Royal Society p.111; MAFF p.73; RBG Kew p.96; NHM p.156). Other important techniques that have already yielded, and may be expected to continue to yield, new data for systematic analysis include electron microscopy, immunology, chromosomal analysis and the application of image analysis to a range of the structural features forming the basis for traditional systematics. Scientists engaged in biological systematic research now need access to laboratories suitably resourced for these new and diverse techniques. The increasing amounts of systematic data, based on both "new" and "traditional" approaches, require the development and application of appropriate computerised taxonomic databases (Bisby pp.196—197; CABI p.43). We consider the application of the newest methods in United Kingdom systematics more fully in chapter 8.

2.22 Whatever the tools, the ultimate aim of biological systematic research still remains that of assigning all living, and indeed extinct, organisms to clearly defined units of classification (taxa) and to arrange these in a system which reflects their evolutionary history. Many witnesses emphasised the need to maintain basic, "traditional" systematic research to form a sustained foundation for these new developments and in order to assimilate their significance (Prance p.94; Patterson p.164; Linnean Society p.134).

The size of the task

2.23 Only a small part of the total range of organisms has been subjected even to alpha taxonomic treatment. Probably a large fraction of living things have yet to be described even at the most basic level. A correspondingly smaller group has been subjected to a beta level of treatment, and of course less still at a gamma level.

2.24 Many witnesses described the enormity of the task. There are approximately 1.4 million described species of organisms (plants, animals, fungi and microorganisms) and until recently the estimate of the actual total number of species in the world was 3—4 million. Following further work in the tropics, this estimate is now put conservatively at 10 million. Such species as have been described are heavily skewed in favour of the temperate regions (1m) rather than tropical (0.4m) even though species diversity in the tropics is known to be greater (Raven p.289). CAB International submitted a useful table of known and *conservatively* estimated numbers of world species which we reproduce at Table 2.1.

TABLE 2.1
The known and conservatively estimated numbers of world species in selected groups of organisms

Group	Known species	Estimated total species	Percentage of species known and described
Mammals	4,000	4,000	100
Birds	9,000	9,100	99
Fish	19,000	21,000	90
Flowering plants and ferns	220,000	270,000	81
Mosses and Liverworts	17,000	25,000	68
Algae	40,000	60,000	67
Insects (incl. all arthropods)	800,000	6,000,000*	13
Bacteria	3,000	30,000	10
Fungi (incl. lichens)	69,000	1,500,000	5
Nematodes	15,000	500,000	3

*Estimates ranging up to 80,000,000 are published, but 6,000,000 has now been arrived at by three different approaches.

2.25 Even amongst the better known genera new species are being discovered all the time. Thus the Index Kewensis recorded 13,604 new species of flowering plants between 1986 and 1990 alone (RBG Kew p.93).

2.26 The task confronting systematic biology research is potentially enormous and the tools for performing it are increasingly sophisticated. Clearly, the resources that can reasonably be committed to the work will always be unequal to the potential demand. Before we consider those resources, we must ask ourselves what are the uses to which systematic biology research may be put.

CHAPTER 3 USES OF SYSTEMATIC BIOLOGY RESEARCH

3.1 In chapter 2 we described what was meant by systematic biology research as an intellectual pursuit in its own right. In that context we found that systematic biology attempts to document the variation of living and fossil organisms under a generally accepted international code of nomenclature. The effect of this is to provide an essential reference system both for other branches of biological science and for a much wider public. The specification of a plant, animal or microbe in the form of its scientific name gives it immediate meaning throughout the scientific world. The science of systematics and the names derived from it therefore provide an international language for applied biology. The uses of systematic biology research are virtually all derived from this.

Biodiversity

3.2 The conservation of biological species has become a major international issue with considerable political momentum behind it. In June 1992 the United Nations Conference on Environment and Development will consider an umbrella agreement or convention on surveying biological diversity (ODA Q 125; WRI p.201). The relevance of systematic biology research to the study and management of the conservation of biological diversity was widely recognised by witnesses (NERC P.27; DOE Q 586; ODA P.43; AFRC P.59). Biological diversity can be measured at three broad levels—genetic variation within species; the variety of species within a particular habitat; and the variety of habitats on the planet. But none of this can be quantified, understood and discussed sensibly without biological systematics.

3.3 Some witnesses went so far as to talk of biodiversity as a synonym for systematic biology, “a new way of describing systematics” (Bridgewater p.21). Prof. Prance, Director of the Royal Botanic Gardens, Kew, spoke of the botanic gardens and natural history museums as “biodiversity institutes” (Prance PP.94–95). While they are, strictly speaking, not synonymous, systematics certainly provides the language of biodiversity—the identity and characterisation of the living

organisms to be conserved. And it underpins the many other scientific questions which preservation of biodiversity poses¹:

- How many species occur in some particular place, association, or community? Why do some of them only occur there and not elsewhere?
- Why do large numbers of different species occur in some groups (genera or families) while others have very few? What is the genetical and historical basis for this?
- What is the degree of genetic diversity within the species in an ecosystem? How does this affect their ability to withstand threat of competition, disease or environmental change?
- What is the minimum size of a given kind of ecosystem which can be sustained without its collapsing?

3.4 The Committee note that Government policy has recognised the importance of biodiversity in framing both its domestic and international environmental policies. Evidence from DOE set this out succinctly and clearly (PP.167—68). And many of us remember the 1990 NERC lecture of the Rt Hon Chris Patten MP, then Secretary of State for the Environment, in which he elegantly set out the Government's commitment to conserving biological diversity, and in particular his appreciation of what United Kingdom science had to offer. Speaking of the United Kingdom collections he then said, "It is important that this material is not only conserved, but studied and experimented with so that the economic potential of its genetic diversity is explored and developed" (Conserving Biological Diversity, 1990 NERC Annual Lecture, Rt Hon Chris Patten MP, 20 November 1990). This acceptance of the importance of systematic biology research to the conservation of biological diversity was confirmed by the proceedings of a two day seminar organised by the Department of the Environment at the NHM on 13—14 June 1991, which some of us attended, (Conserving the World's Biological Diversity; How can Britain Contribute?).

3.5 Individual scientists who gave evidence to us stressed the urgent need to expand our knowledge of biological diversity before much of it is destroyed (Prance P.94; May p.139; Linnean Society p.133; Systematics Association p.185). In their view, this urgent time dimension should put systematic biology research in a unique position for increased funding and resources. The World Resources Institute told us that the 1990s would see a greater recognition of the role of systematics in guiding basic conservation decisions, in identifying new uses of biological diversity and in bringing benefits to the countries who have command of its skills (WRI p.201).

Economic Applications

3.6 The applications of systematic biology are legion. For example a recent U.S. publication "Floristics for the 21st Century" listed 46 different professions which might use systematic information in national or regional database form. Some applications on which we received evidence are particularly important because of their economic value. They all involve the necessity for accurate specification. As one witness wrote, to question the utility of biological systematic research was equivalent to asking a chemist "the utility of knowing whether a chemical is sodium chloride or sodium cyanide" (Clarke p.52).

3.7 *Medicine*: The specification of microbes causing disease—protozoa, bacteria, fungi, viruses—is the province of systematic microbiology. The correct identification of a pathogen (which will dictate remedial treatment) is fundamental to human and veterinary pathology. An important part of medical research focuses on the systematics of human disease pathogens (MRC p.142; PHLS, p.282). The Linnean Society emphasised the importance of specific and even subspecific identification of disease organisms, such as malarial parasites, for example in drug resistance work. The price of "getting it wrong" in this field may be fatality or serious disability. Where consumption of toxic biological material is involved in an emergency, rapid identification of the causal agent is essential to appropriate treatment. RBG Kew is routinely called upon to give this high-speed identification service.

3.8 Systematics is also necessary in veterinary and medical science in identifying carriers (vectors) of disease organisms—for example mosquitoes, ticks and blackflies—and of their intermediate hosts, for the purpose of control.

3.9 *Pharmaceutical industry*: The correct identification of plants and animals, and increasingly of fungi—used as the source for drugs—is again a life-or-death matter. Although many drugs are now of synthetic origin, a significant number are still derived directly from plants and fungi.

¹ This was described at the DOE/NHM Seminar, *Conserving the World's Biological Diversity; How can Britain Contribute?*, 13—14 June 1991.

Systematic research on the fungal groups exploited in this way underpins their use in the pharmaceutical industry, and culture collections of such organisms are of equal importance to industrial and academic users (SmithKline Beecham, p.185). Kew told us a fascinating tale of how the predictive use of systematics enabled them to track down a suitable source of the hydroxy alkaloid castanospermine, currently the subject of AIDS research. The source in question was a South American tree of the genus *Alexa*. Such work would have been impossible without appropriate research facilities (RBG Kew p.92).

3.10 *Agriculture:* The identity of crop plants, of their fungal and insect pests, and of weeds are all essential to a scientific basis for agricultural practice. The identification of fungal pathogens and pests of crops and stored products forms a significant part of the international services offered by CAB International (CABI) (pp.138—139). The research underlying crop breeding for disease and pest resistance and increased yields depends on reliable systematic treatment of the crop, the plant, the pest and the pathogen. Wild relatives of crop plants such as wheat, rice and potatoes often possess valuable genetic characters that give resistance to diseases, pests or environmental stresses (Linnean Society p.133). These may in turn be incorporated into new resistant agricultural cultivars (a cultivar is a population of plants within a species, cultivated by man and showing certain characteristics which he has selected). An underpinning of systematic research is essential to a wide range of food safety and animal health issues, and to the control of the release of genetically modified organisms into the environment (AFRC p.59). Important reference collections of organisms responsible for diseases of animal stock and poultry are held in several laboratories under the aegis of the Ministry of Agriculture, Fisheries and Food (MAFF) (MAFF p.72).

3.11 *Industrial fermentation, biotechnology:* In these areas of applied microbiology, in brewing and a wide range of other industrial processes, the identity of the microorganisms involved, down to the molecular level of their genetic makeup, is a specialist area of microbial systematics. As the value of the exploitation of genetically engineered microorganisms comes to be recognised in their protection by patent rights, so the science of their identification becomes a central element in industrial biotechnology (Unilever p.189—90).

3.12 *Fisheries:* The problems associated with over-fishing, and the legislation needed to control it, coupled with those associated with parasitic diseases of fish, all involve systematic research (Beverton p.237). The fisheries laboratory at Weymouth, for example, maintains a systematic collection of fish pathogens (MAFF p.72) and identification of the fishes themselves often poses major problems.

3.13 *Customs control:* Legislation relating to the import and export of animal and plant species under the Convention on International Trade in Endangered Species (CITES) requires accurate identification, to establish the status of the material submitted for customs clearance. There are also many regulatory provisions where narcotic plants and fungi are specified, requiring accurate systematic assignment (RBG Kew p.92).

3.14 *Biological recording:* The central role of biological systematics in biological recording and monitoring systems—and hence to so much environmental and ecological work—was emphasised in their evidence by the Coordinating Commission for Biological Recording (CCBR p.56): “... unless there is a sound basis of systematic biology such records are useless. Inadequate, or ineffectively applied taxonomy leads to inaccurate conclusions, spurious or misleading correlations, mistaken or damaging actions, and general confusion.”

3.15 *Water Pollution:* Assessment of aquatic environmental quality depends on information on aquatic organisms. As the National Rivers Authority (NRA) told us, “Rivers are best understood in biological terms ...”. NRA uses a River and Invertebrate Prediction and Classification System as a measure of water quality. Biological data are also used to measure environmental damage and for conservation. Taxonomic precision is of the essence. NRA rely heavily on the “institutional base of biological systematics R&D” (NRA pp.152—3).

3.16 *Biological systematics as recreation:* There are a number of leisure activities, from amateur horticulture to bird watching, in which an extensive research base underpins the hobby activity of a large number of people. The reliable identity of a rare bird or beetle, or a particular houseplant variety offered for sale (RHS P.177) are products of a background of systematic research in ornithology, entomology, and botany respectively.

Cost and Value

3.17 If a monetary value is to be placed on biological systematic research, it can be seen in at least three ways—the cost of getting it wrong; the cost of its not having been done; and the value of selling systematic data.

3.18 *The cost of getting it wrong*: In the case of a pathogen being mis-identified, the cost may be the death of the patient, the crop or the livestock. The Public Health Laboratory Service listed the difficulties of specifying *Salmonella* and *Legionella* organisms and how the effects of other disease causing organisms like *Neisseria meningitidis* were being combated through research based on systematics (PHLS p.282).

3.19 Attempts to control pests have been thwarted when prevention measures were based on a mis-identification or systemic misunderstanding. Sir John Burnett (p.34) cited several examples of the central importance of accurate and precise systematic research where wrong decisions had led to serious financial losses. The taxonomy of the fungus, *Gliocladium virens*, which produces the soil toxin Gliotoxin, was for several years confused and a number of companies spent years of fruitless R and D using the wrong species. Similar instances have involved disease-causing fungi, and CABI emphasised the need for work on these, both at and below the species level (CABI pp.40—41).

3.20 Dr Harris of CABI described the vital role played by insect taxonomists in accurately identifying the North American screw-worm recently accidentally introduced into Libya. Only rapid identification allowed a large scale international eradication programme to be implemented (Q 560).

3.21 Recent work on the systematics of the blackfly *Simulium*, vector for a parasitic worm causing river blindness, has enabled only those species responsible to be targeted—to great effect medically, economically, and environmentally.

3.22 *The cost of its “not having been done”*: It is much harder to quantify the cost of failing to carry out systematic biology research. Such records of the characteristics and identity of any group of organisms is the starting point for almost any scientific work on their biology, ecology, or biochemistry. Inevitably there would be the cost of having to buy in the knowledge were the research not performed. And as species disappear the opportunity costs of never having known anything about their attributes could be high.

3.23 *Selling the data*: Some value can of course be seen in the saleability of the data store produced by systematic research. 5—6,000 sets of *Flora Europaea* have been sold by Cambridge University Press for example (Bisby p.15). Even here, sale value is perhaps deceptive in that publication can never be made to bear the full cost of production, which may represent many years of work by a sizeable team of systematists. Work on third world biological systematics is primarily of use in the country concerned, and has the greatest impact there by its influence on conservation activity, ecological surveys and assessment of biodiversity, but the number sold in the “target” area may be quite small. “Taxonomic publications relating to tropical countries and produced in the United Kingdom are available (only) in very small numbers in these countries” (Heywood p.98). Dr Bisby told us that while species information systems and databases “may in time come to recoup a major fraction of running costs through charging, ... the initial investment cannot be recovered”. The initial costs of the *Species Plantarum* and *Global Plant Species Information System* of which he spoke were £20m (Bisby p.13). Given these circumstances, it would perhaps be misleading to try to see the value of such work in terms of the profit derived from sale of such publications.

COMMITTEE OPINION

3.24 Systematic biology research provides an essential framework to most other branches of biological science where its benefits to mankind both in economic and human terms can be large.

3.25 It also has a particular claim to attention at present because of the emergence of the conservation of biological diversity as a major international political as well as a scientific and environmental issue, where time is of the essence. The quality of the collections and the expertise of our systematists places the United Kingdom in a unique position to contribute a firm scientific basis to this movement, in innumerable theoretical and practical ways.

3.26 Systematics research and the curation of the collections on which it depends should therefore be maintained in good order.

CHAPTER 4 PERFORMERS

4.1 In this chapter we take a quick look at the principal players and their paymasters, the resources at their disposal and the work they do. Because of the importance of reference collections to research, much systematic biology research is located within the institutions housing those collections. It is not our intention in this chapter to catalogue the activities of every centre of research and the features of every systematic collection, but rather to identify the different groups and to attach some statistical weight to their importance in the total picture¹. This latter exercise is possible using the results of a survey we ourselves conducted, the terms of which are set out in Appendix 2.

Museums

4.2 The national museums, particularly the Natural History Museum (formerly the British Museum (Natural History)), and certain leading university and provincial museums play a major role in systematic biology research and in housing the collections.

4.3 *The Natural History Museum* (NHM) deserves particular mention. Housed in Victorian gothic splendour at South Kensington, the NHM is probably the finest museum of its kind in the world. Behind its public galleries lie a vast collection of some 67 million specimens covering zoology, entomology, palaeontology, botany and mineralogy, and the largest natural history library in the world. But as the Museum was at pains to point out, the NHM stands not simply as a "glory to the past" (NHM p.154) but as an active research centre. Its research activities include international projects to determine the correct scientific names for plants of agricultural and horticultural importance; identification services in support of governmental and non-governmental enforcement of agreements on conservation and trade in endangered species; advice to governments on control of pests and weeds; and establishing international standards for geological ages through the systematic study of fossils (NHM p.154).

4.4 In furtherance of its work, the museum tries to stay at the cutting edge of new developments in science. It has, for example, funded with help from the research councils a new DNA facility and fully recognises the areas in which future developments might lie—like the building of better databases, automated techniques for identification, or for DNA and RNA analysis (NHM p.156).

4.5 *Other nationally funded museums*—in Wales, Scotland, Ulster, and Merseyside—also play a leading role in research and curation. Thus we were told by the National Museum of Wales that they had "a strong commitment to the practice and furtherance of research in systematic biology, including palaeobiology", centred around its collections in the departments of Botany, Geology and Zoology (NMW p.150).

4.6 Some university and provincial museums are also important in the field and we received evidence from a number of them. (All biological collections outside the NHM and the Royal Botanic Gardens were exhaustively documented by the 1987 Museums Association survey.) As can be seen from Table 4.1, the collections of the Universities of Oxford, Manchester and Cambridge actually exceed some of the national collections in size.

4.7 Our own survey data set out in Table 4.2 shows that in 1990 museums represented 34 per cent, both of total expenditure on systematic biology in the United Kingdom and of manpower as expressed in man years. If we separate curation from research we see that museums accounted for 27 per cent of the total United Kingdom spend on systematic biology research. The pre-eminent position of the NHM in research is readily apparent—it alone accounted for 24 per cent of the United Kingdom total.

¹ The principal collections and centres of research were described in *Taxonomy in Britain*, ABRC, 1977, Chapter 5 and Tables 1–12. The Museums Association published an exhaustive survey of museum biological collections, *Biological Collections UK*, in 1987.

TABLE 4.1
*Estimates of the number of biology specimens (thousands) in major United Kingdom museums
(excluding palaeontological material)*

Rank	Museum	Botany	Zöology	Total	Curators	Administrative Type
1	NHM	3,000	30,000	33,000	101	national
2	Oxford	400	9,000	9,400	3	university
3	Edinburgh	2,000	5,000	7,000	10	national
4	Kew	6,000	0	6,000	52	national
5	Manchester	2,000	3,500	5,500	5	university
6	Cambridge	500	1,700	2,200	6	university
7	Cardiff	222	1,000	1,222	10	national
8	Liverpool	134	691	826	6	national
9	Brighton	19	774	794	2	local authority
10	Belfast	60	500	560	6	national
11	Norwich	34	443	477	3	local authority
12	Birmingham	49	287	336	3	local authority
13	Exeter	42	228	270	2	local authority
14	York	43	207	250	1	local authority
15	Bolton	48	176	224	3	local authority
16	Bristol	12	110	122	3	local authority
17	Sheffield	8	71	79	2	local authority

TABLE 4.2: Resources Allocated to Systematic Biology in 1990

	(a) Expenditure (£ million)			(b) Manpower (Man Years)		
	Total	%		Total	%	
Natural History Museum*	8.00	26.1		270.0	24.6	
Other National Museums	2.07	6.7		84.6	7.7	
Other Museums	0.44	1.4		17.6	1.6	
Total Museums	10.50	34.3		372.2	34.0	
Royal Botanic Gardens (Kew)**	3.96	12.9		151.5	13.8	
Royal Botanic Garden (Edinburgh)	0.97	3.2		41.0	3.7	
Other Gardens	0.22	0.7		2.9	0.3	
Total Gardens	5.15	16.8		195.4	17.8	
University Departments	4.16	13.6		157.7	14.4	
Polytechnic Departments	0.13	0.4		9.9	0.9	
Total Higher Education	4.30	14.0		167.6	15.3	
AFRC Institutes	0.63	2.1		20.5	1.9	
NERC Institutes	3.06	10.0		96.6	8.8	
MRC Institutes	0.28	0.9		9.5	0.9	
Total Research Councils	3.97	13.0		126.5	11.5	
DH	0.78	2.5		20.0	1.8	
DoE***	0.50	1.6		0.0	0.0	
Forestry Commission	0.43	1.4		5.0	0.5	
MAFF	1.03	3.4		18.8	1.7	
ODA (ODNRI)	0.04	0.1		2.6	0.2	
SOAFD	0.16	0.5		2.6	0.2	
Total Government Departments	2.94	9.6		49.0	4.5	
CAB International	2.20	7.2		95.0	8.7	
Other Organisations	1.54	5.0		90.0	8.2	
Total	30.60	100.0		1095.6	100.0	

*NHM figures exclude general overheads and cost of collection maintenance.
**RBG (Kew) were unable to separate research from curation; for the purpose of this study we have assumed a 50:50 split.
***No manpower figures were provided by DoE.

Gardens

4.8 *The Royal Botanic Gardens* at Kew and Edinburgh are, along with the Natural History Museum, the two other major institutions engaged in systematic biology in the United Kingdom today. Kew, for example, holds 6 million botanical specimens, of which about 25,000 are living specimens. It administers the *Index Kewensis*, which holds data on all new plant names worldwide, and is actively engaged in molecular research as well as more traditional systematics (RBG Kew PP.93—4). Evidence from RBG Edinburgh exhibited a wide range of research activity (Scottish Office QQ 308—319, PP.80—82).

4.9 Table 4.2 shows that in 1990 gardens represented approximately 17 per cent both of total expenditure on systematic biology in the United Kingdom and manpower as expressed in man years. The NHM and the RBG (Kew) between them accounted for over a third both of spending and research activity.

Universities and Polytechnics

4.10 Although, as we shall consider more fully in chapter 6, systematic biology has suffered considerable decline at universities, they are still major performers in systematic biology and represent about 14 per cent of total expenditure and manpower. In research they represent about 19 per cent of the spending and 23 per cent of the manpower. Polytechnics play a much smaller part. Of the 49 universities and 7 polytechnics who responded to our survey, almost 80 per cent conducted some research. The range of activity was very wide however.

4.11 Those universities and colleges which in academic terms perform a substantial amount of systematic biology research (ie over £150,000 p.a.) were Cambridge, Cardiff, Glasgow, Oxford, Reading and Swansea.

Research Council Institutes

4.12 Work in systematic biology is to be found at institutes and units run by the *Natural Environment Research Council* (NERC)¹, the *Agricultural and Food Research Council* (AFRC)² and the *Medical Research Council* (MRC). (This activity is, of course, in addition to the work which they fund but which is performed elsewhere, principally in the universities.) NERC told us that “almost all the major NERC institutes include some systematic biology within their programmes” and that a number of them contain important reference collections. Thus the British Geological Survey housed one of the two major United Kingdom fossil collections; the British Antarctic Survey had established a Terrestrial and Freshwater Resource Centre to house living and dead specimens, and databases; the Institute of Freshwater Ecology and Dunstaffnage Marine Laboratory housed the Culture Collection of Algae and Protozoa. NERC told us of their support for new molecular research methods at their institutes (NERC PP.26, 29).

4.13 AFRC’s research was focused on biological control strategies; micro-organisms causing disease; and identification and preservation of useful genes in breeding populations of plants and animals and the production of transgenic plants by introducing engineered genes into existing crop plants. In connection with their work, they maintained at their various institutes some twenty one collections eg microbial, viral, arthropod, nematode, organisms of the phylloplane (leaves) and rhizosphere (roots), food and animal pathogens, wheat, barley, oats, pea, other vegetables, arabidopsis, antirrhinum and animal gene pools (AFRC PP.59—62).

4.14 MRC’s evidence to us showed how, in medicine, knowledge of the differences between molecules and between cells were as important as the differences between organisms as a basis for the rational prosecution of research. Systematics was used as a tool in their “problem-oriented” research mission MRC p.141.

4.15 Table 4.2 shows that in 1990 spending by these three research councils represented about 13 per cent of total expenditure and manpower in systematic biology in the United Kingdom. Not surprisingly their contribution to research effort is, relatively speaking, much stronger—representing 22 per cent of expenditure and 20 per cent of manpower.

¹ British Geological Survey; British Antarctic Survey; Institute of Freshwater Ecology; Dunstaffnage Marine Laboratory; and Institute of Oceanographic Sciences Deacon Laboratory.

² Institute of Plant Science Research; Institute of Arable Crops Research; Institute of Grassland and Environmental Research; Horticulture Research International; Institute of Food Research; Institute for Animal Health; and the Arabidopsis Seed Resource Centre at the University of Nottingham.

Government Departments

4.16 A number of Government Departments—the Ministry of Agriculture, Fisheries and Food (MAFF), the Scottish Office Agriculture and Fisheries Department (SOAFD), the Overseas Development Administration (ODA), and the Department of Health (DH)—also engage in systematic biology research and curation of collections at their own institutes.

4.17 Thus MAFF's scientists use systematic biology in protecting the United Kingdom from pests, diseases and weeds and in policing plant health import legislation and pesticide use regulations. The systematics of pathogens (fungi, bacteria and viruses) is the starting point for controlling diseases of crops and livestock, fish and shellfish. It is also the framework within which plant breeding, the conservation of diversity and the genetic modification of organisms is carried out. MAFF works closely with RBG Kew, which it funds, with CABI, which it funds on behalf of the United Kingdom, and with AFRC and SOAFD. But it also has its own research facilities in the Central Science Laboratories, some of which house collections. Central Science Laboratory (CSL) Slough houses a collection of invertebrates known to cause economic losses of stored products and CSL Harpenden maintains the National Collection of Plant Pathogenic Bacteria. The Central Veterinary Laboratory maintains a number of collections associated with foot and mouth disease. MAFF also maintains various International Reference Laboratories, and provides assistance to the National Collection of Industrial and Marine Bacteria which it has recently transferred to the University of Aberdeen (MAFF PP.70—72).

4.18 In Scotland, systematic biology research is conducted by the SOAFD Agricultural Scientific Services Laboratory, in support of statutory responsibilities for cultivar testing, and by the Scottish Crop Research Institute as part of wider programmes of research into crop genetics and breeding, and in studies of plant pathogens and pests (SOAFD PP.80—81).

4.19 ODA regularly commissions work from other institutions like NHM, CABI, and Kew in connection with its assistance to developing countries (ODA PP.42—45; QQ 135—9). But its role as a performer is relatively small and centred at their Natural Resources Institute (NRI) where an extensive programme of research on integrated pest management is carried out. Collections of grasshoppers and termites are to be transferred to NHM shortly (Q141). It would appear that NRI are anxious to become research managers rather than performers in this field.

4.20 The *Department of Health* (with the Welsh Office) performs research involving systematic biology in its Public Health Laboratory Service. Its principal laboratories are the Centre for Applied Microbiology and Research (CAMR) at Porton Down, the Central Public Health Laboratory (CPHL) and the Communicable Disease Surveillance Centre (CDSC) in North London. In carrying out their functions these laboratories and the 52 regional laboratories "depend greatly on the ability to identify microbes precisely and to perform detailed typing within species". Systematic work is carried out chiefly at the Reference Laboratories, most of which are located at CPHL. In connection with its work, the PHLS maintains the national Collection of Type Cultures (which consists of pathogenic bacteria of medical and veterinary importance, as well as plasmids), the National Collection of Pathogenic Fungi, and the European Collection of Animal Cell Cultures (which serves as a deposit for patents and provides cell lines for the biotechnology industry). PHLS regretted that there was as yet no United Kingdom national collection for viruses (PHLS p.282).

4.21 The *Forestry Commission* reported certain key areas where there was a significant interest in systematics—studies of natural tree populations, collections of worldwide tree species, and studies of insects and fungi affecting forestry. The Commission has two research stations (Alice Holt Lodge and Bush Estate) and two arboreta (Westonbirt and Bedgebury) (Forestry Commission p.247).

4.22 Table 4.2 shows that, taken together, Government Departments are major performers of systematic biology research in pursuance of their own objectives and substantial holders of reference collections. Both their total and research spending figures represented about 9 per cent of the United Kingdom total in 1990. In terms of manpower, however, Government Departments only accounted for about 4 per cent of both total and research manpower resources dedicated to systematic biology.

CAB (International)

4.23 CABI is a non-profit making intergovernmental organisation based at Wallingford. It is owned by 29, mainly Commonwealth, countries. It operates four specialist institutes providing world services in the fields of biological control of weeds and pests, entomology, mycology and parasitology—the International Institute of Biological Control (IIBC), the International Institute

of Entomology (IIE), the International Mycological Institute (IMI), and the International Institute of Parasitology (IIP).

4.24 These institutes are major performers of research chiefly in support of the identification services provided for member governments and to non-member governments on a commercial basis. CABI institutes also maintain reference collections. IIE uses the collections of the NHM where most of the Institute's researchers are based. IIP maintains extensive spirit and slide reference collections with over 120,000 samples of animal helminths and plant nematodes and 200 living cultures of the latter. IMI maintains its own dried reference collection of 340,000 specimens. IMI also holds the United Kingdom National Collection of Fungus Cultures for which it received special government funding of £40,000 a year in 1989–90, and which it considered to be inadequate. CABI is a major publisher of scientific papers and books (CABI, PP.37–38).

4.25 Table 4.2 shows the prominent role played by CABI in systematic research.

Private Sector

4.26 Some research and curation of collections is conducted privately. The Linnean Society, for example, holds the collections of Linnaeus, purchased from his widow at the end of the 18th century. Though the Society does not engage in research itself its members do in other guises. Private gardens like the Chelsea Physic Garden with its one researcher and the gardens belonging to the National Council for the Conservation of Plants and Gardens (which coordinates the work of the 558 National Plant Collections) are also valuable resources (Chelsea Physic Garden p.49; NCCPG p.142–4).

4.27 Pharmaceutical firms use systematic biology in their research, as evidence from SmithKline Beecham (SB) attested. SB's systematic work appears in the main to be conducted on their behalf at the universities. The Company does, however, deposit cultures in pursuance of patent applications (SmithKline Beecham p.184).

4.28 Amateur interest has always sustained systematics and continues to do so, though by its nature is unquantifiable. Amateur interest in birds, wild flowers and horticulture generates a considerable market for publications on the identification of these groups—like the *Flora Europea*—which are themselves the products of systematic research. And there are still amateur collectors.

4.29 In financial terms however the role of the private sector as performers of systematic biology research is very slight and did not figure in our survey.

The Funders

4.30 So far in this chapter we have looked at systematic biology research under the various categories of performers. In our view that is the most profitable way in which to approach the subject and its problems. But it is worthwhile looking quickly at systematic biology research and the curation of collections from the vantage point of the funders.

4.31 As we can readily deduce, the funding of most systematic biology research and curation falls upon the public purse. The work of the research councils, in their own institutes and through grants at universities and polytechnics, is funded out of the DES Science Budget. Work conducted in universities and polytechnics without research council support is facilitated by DES funding of university research facilities through the UFC and PCFC. Government Departments obviously fund their own activities, while MAFF also funds the United Kingdom's contribution to CABI.

4.32 The position of museums and gardens is more complicated because they have made valiant efforts to attract funding from private sources and some of them (NHM and RBG Kew) charge for admission. Thus out of a total income of £29.1m in 1989–90, NHM raised £2.7m through commercial activities and £1.5m from admissions (OAL P.13). Total self generated income came to £7.1m. But of course this is not necessarily available for research. The costs of earning this income are considerable and the amount available for research from this and other private sources is very small. The fact remains that overwhelmingly the major part of research funding must come from government sources.

4.33 Thus RBG (Kew) is funded by MAFF; RBG (Edinburgh) by the Scottish Office Agriculture and Fisheries Department; the NHM and the National Museums of Merseyside (The Liverpool Museum) by the Office of Arts and Libraries; the National Museum of Wales by the Welsh Office; and the National Museums of Scotland by the Scottish Office; and the Ulster Museum Belfast, by the Northern Ireland Office. University museums are funded by the universities and hence

indirectly by DES through the UFC, while local authority museums are in the main funded from local funds, supplemented by any payments they may receive through the Area Museums Councils and which ultimately are provided by the Office of Arts and Libraries.

COMMITTEE OPINION

4.34 Systematic biology research is thus ultimately and properly very much a publicly funded activity as are the collections on which it depends. But it is unusual in the range both of its paymasters and of its performers and this bears on our consideration of funding problems, to which we now turn.

CHAPTER 5 DECLINE IN RESEARCH DURING THE 1980s

5.1 The principal issue confronting systematic biology research in Britain today is the question of funding. There was complete consensus amongst our witnesses that provision for systematic research (and, so far as the institutions were concerned, curation) had declined and that it was now inadequate. The principal reason advanced was the decline in core funding of major institutions by the Government in furtherance of their public expenditure policies. The policies of the research councils and the decline of UFC funding were also blamed.

5.2 *Core funding:* Vociferous complaints were made in many quarters in respect of the relative decline in core funding of the Natural History Museum. The Government's grant-in-aid over the decade had fallen in real terms and the museum's valiant attempts to raise money from the private sector and its own resources had failed to make up the shortfall. In its Corporate Plan for 1990–95, the Museum announced that it would henceforward concentrate its research efforts into six areas—biodiversity, environmental quality, living resources, mineral resources, human health and human origins. It announced that in addition to the 50 posts lost since 1983–84, out of a total Museum establishment of 865, it would not seek to fill the 40 plus posts lost through natural wastage since 1989 and would look for a further reduction in 50 to 60 posts in the current financial year, 1991–92. Over the period as a whole the changes in science staff showed a reduction of nearly 100 posts from 350 to 256 in June 1991, when the Museum establishment was about 730. When all the changes have taken place, the expected establishment for science by the end of 1992–93 will be about 250 of whom 70 will be engaged in research across all aspects of natural history, including mineralogy.

5.3 The Corporate Plan also announced a change in curatorial policy which we consider further in chapter 6. Even after these changes, the Museum predicts a cumulative deficit of £4.4m by 1994–95. The outcry that followed publication of the Corporate Plan, the grim financial prospects it contained, and the unpalatable consequences (as many saw them) for research and curation, led in part to our Committee's undertaking the present inquiry.

5.4 Complaints from and about the other institutions were less shrill. The Keeper of Liverpool Museum which, like the NHM receives OAL grant-in-aid (see chapter 4 above) stated that "the main problem we have overall is the divergence between the rate of inflation and the grant-in-aid that is given to us: they do not match and there is always a shortfall" (Q 1093); RBG Kew thought current support for the activities across the board was "insufficient" (p.93); that current funding represented 75 per cent of what they would like to have—for example to refill empty posts currently running at 10 per cent in systematics (Q 340); and that "The major collections must have a secure funding base. At present their funding base is not secure" (p.96). RBG Edinburgh appeared to have rather greater confidence in the provision made for it by SOAFD (p.109).

5.5 *Research Councils:* Systematic biology research has not fared well in competition with other branches of biological science for research council funding. The Director of the NHM told us that he had the assurance of the Chairman of the ABRC that research applications would be treated on their merits along with other areas (Q 682). But there was "corridor talk" that applications for grants in systematics were not in fact looked upon with great favour in comparison with those from other areas of biological sciences (Q 681).

5.6 This was borne out by research council evidence. The SERC received "almost no 'classical' taxonomy research applications: these do not fare well alongside more innovative research approaches and are arguably more within the remit of NERC and the NHM than SERC" (p.179). But NERC claimed that, unless a research application was made in the context of a particular environmental change, they would expect SERC to fund it (Buttle Q 68). NERC were confident, however, that discussions between research councils prevented applications from going unconsidered (QQ 69–71).

5.7 The problems of meeting research councils' criteria of originality meant that many systematic biology research applications would inevitably fail as they were "service" based rather than "hypothesis" based (Linnean Society p.133; Stace Q 757; Lawton Q 783; CABI p.45). Of 35 systematic research applications received for grants by SERC in 1980–90, only 3 were awarded (Stace Q 757). The Royal Society also held the view that the subject would "be squeezed on to the edges of all the research councils dealing with this area" (Follett Q 397).

5.8 We also discovered in evidence that while NHM had, since 1987, been eligible to apply to the research councils for grants, the situation regarding the eligibility of the other museums was far from clear. Wales and Liverpool, for example, both considered themselves ineligible to receive research council grants (Q 1104 and Q 1048). Although Manchester considered themselves eligible, they felt that there was very little hope of actually getting systematic biology grants, because "they are not seen as the current thing" (Q 1054–55). Discussion with the ABRC and individual research councils suggests that while in principle there is nothing to prevent the museums (or any other institution for that matter) applying for research grants, only the NHM (because of assurances made by the Government when responsibility for its funding was transferred from DES to OAL) was likely to be successful.

5.9 *Universities:* University based research has declined because the subject in general has declined. As we shall show more fully in chapter 7, the growth of new areas of biological science—mainly molecular and biochemical—is associated with a decline in the number of university appointments in systematics. What might have been no more than a readjustment in the faculties to accommodate new growth areas of knowledge was however exaggerated by the pressures of university funding.

5.10 Universities have been under ever increasing pressure to attract external research funds, including research council funds, and appointments have increasingly been influenced by this criterion. Systematic biology is by its nature not a great generator of external income. As one witness told us "... taxonomists cannot help a lot in that field. I know two Fellows of the Royal Society who are taxonomists who never had a single research grant in the whole of their lives" (Stace Q 731).

5.11 The result of all these factors is, as one witness told us, that "... the number of well-founded centres in the United Kingdom where one can undertake high quality taxonomic research is very small, as is the number of staff who have built up such facilities and who have access to research grants. It has become a vicious circle" (Heywood Q 866).

5.12 University-based research has further suffered from some of the side effects of UFC's method of funding the research base. Systematic biology research is often carried out with little or no outside funding, using only the resources of the "well-found" laboratory. But resources for research on this basis have come under pressure because universities make inadequate charges for indirect costs of research funded from elsewhere. And further pressure will be felt following the proposed transfer of the so-called "DR" element in university funding (payable to universities in support of research council grants) from the UFC to the research councils themselves. (The history of this proposal is set out in our report, *Science Budget 1991–92*, Session 1990–91, HL Paper 37-I, pp.15–16.) For a subject like systematic biology which does not attract outside moneys the current position is likely to get worse.

5.13 Our evidence on funding was quantitatively weak however. For the institutions, figures of expenditure often failed to distinguish between research and curation. Some even included buildings and other costs. Evidence from the universities contained virtually no figures at all. Only one witness, CAB International, made a valiant stab at estimating the total spend on systematic biology research and curation. No witness attempted to provide year-on-year figures.

5.14 This was another reason for conducting our own survey of expenditure on systematic biology research and the related activities of curation and information services, and on university activity, details of which are set out at Appendix 2. The survey not only yielded much valuable information but—because the returns were often compiled by non-systematist administrators—proved to be a useful corroborative device.

5.15 Our study showed that total expenditure on systematic biology (research, curation and information services) had remained fairly constant in real terms over the last 10 years at about £30m in 1990 prices (Table 5.1). It also confirmed the importance of museums and gardens in the picture as a whole (Table 5.2). Looking specifically at research, however, we found that expenditure dropped 6 per cent in real terms from £17.5m in 1980 to £16.5m in 1990 (Table 5.3). If we distinguish between the different categories of performer we find that there was a decline in spending on

research carried out by museums both in absolute terms (from £5.9m in 1980 to £4.4m in 1990) and relative to their other activities (from 55 per cent of their expenditure in 1980 to 42 per cent in 1990) (Table 5.3 and Appendix 2, Annex 7). Research expenditure at research council institutes and at higher education institutions also declined slightly in real terms while research spending at gardens, government laboratories and other organisations actually rose (Table 5.3).

TABLE 5.1:

Total Expenditure on Systematic Biology

Expenditure (£million)	1980	1985	1990
Current prices	16.3	21.7	30.6
Constant 1990 prices	29.9	28.6	30.6

TABLE 5.2:

Expenditure by Category of Performer

Category of Performer	£m (1990 prices)			% Total Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	10.8	10.6	10.5	36	37	34
Gardens	4.2	4.0	5.2	14	14	17
Higher Education	4.8	4.3	4.3	16	15	14
Research Council Inst.	4.8	4.3	4.0	16	15	13
Government Labs/Depts.	2.7	2.7	2.9	9	9	10
Other	2.7	2.9	3.7	9	10	12
Total Expenditure	29.9	28.6	30.6			

TABLE 5.3:

Research Expenditure by Category of Performer

Category of Performer	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	5.9	5.6	4.4	34	34	27
Gardens	1.9	1.8	2.4	11	11	15
Higher Education	3.7	3.1	3.2	21	19	19
Research Council Inst.	4.2	3.7	3.6	24	23	22
Government Labs/Depts.	1.2	1.2	1.6	7	7	9
Other	0.7	0.9	1.3	4	6	8
Total Expenditure	17.5	16.3	16.5			

5.16 Analysis of research expenditure by source of funds is particularly valuable as it shows a sharp fall in the level of support for research from core funding (principally from Government to the museums and gardens and research council institutes) and from research councils (through research grants or "responsive mode" funding). Core funding for research fell from £11.5m in 1980 to £10.4m in 1990. Research Council funding fell from £3.3m to £2.0m (Table 5.4). This confirms the opinions voiced by many of our witnesses.

TABLE 5.4:
Source of Funds for Systematic Biology Research

Source of Funds	£m (1990 prices)			% Total Funds		
	1980	1985	1990	1980	1985	1990
Core Funding	11.5	11.2	10.4	65	69	63
Research Councils	3.3	2.3	2.0	19	14	12
Government Depts	1.2	1.7	1.8	7	10	11
Commercial Organisations	0.4	0.2	0.9	2	1	5
Self-generated income	0.7	0.4	0.7	4	3	4
Other	0.5	0.5	0.7	3	3	4
Total Expenditure	17.5	16.3	16.5			

5.17 If we turn to research manpower as expressed in man years, we find that data broadly bear out the expenditure pattern after the expected delay. This perhaps is hardly surprising because in systematic biology salaries costs account for about 75 per cent of total research costs (Table 5.5). Thus, while total manpower fell by about 3 per cent between 1980 and 1990, research manpower fell by 7 per cent from 552 to 514 (Table 5.6). If we look more closely at research manpower by category of performer the data are very revealing. While research manpower as measured in man years rose by about 13 per cent at national gardens it fell by between 5 and 9 per cent at research council institutes and at universities. However there was a fall of over 25 per cent at national museums from 153 to 114 man years of research effort (Appendix 2, Annex 7). These figures, moreover, exclude the effects of the most recent developments at the NHM.

TABLE 5.5:
Breakdown of Research by Category of Expenditure

Category of Expenditure	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Salaries	13.1	12.4	12.1	75	76	73
Equipment	1.3	1.2	1.5	8	8	9
General Overheads	2.4	2.2	2.5	13	13	15
Other Activities	0.7	0.5	0.5	4	3	3
Total Expenditure	17.5	16.3	16.5			

TABLE 5.6:
Manpower Engaged in Systematic Biology by Category of Activity Performed

Activity	Manpower (MnYrs)			% Total Manpower		
	1980	1985	1990	1980	1985	1990
Research	552	547	514	49	50	47
Curation	319	306	324	28	28	30
Information Services	132	124	131	12	11	12
Other	123	125	127	11	11	12
Total Manpower (MnYrs)	1125	1101	1096			

5.18 Data on the employment status of research manpower also lend support to the view that systematic biology research is under financial pressure. Performers are responding by cautious staffing policies which include a marked increase in the percentage of researchers employed on fixed term contracts (up from 9 per cent in 1980 to 30 per cent in 1990), especially in museums (up from 1 per cent to 34 per cent) (Table 5.7).

TABLE 5.7:
Employment Status of Research Manpower

Type of Employment:	1980		1985		1990	
	%P ¹	%C ²	%P ¹	%C ²	%P ¹	%C ²
Museums	99	1	95	5	66	34
Gardens	98	2	98	2	86	14
Higher Education	75	25	63	37	57	43
Research Council Inst.	93	7	87	13	64	36
Government Labs/Depts.	100	0	90	10	76	24
Other	90	10	82	18	87	13
Average (All Organisations)	91	9	85	15	70	30
Total Manpower (MnYrs)	552		547		514	

1. % Permanently employed. 2. % Employed on fixed term contracts.

5.19 This information has to be considered in the light of expenditure on other areas of science. The DES Science Budget, for example, increased by 28 per cent in real terms between 1980–81 and 1990–91 (*Science Budget 1991–92*, Session 1990–91, HL Paper 37-I, p.18). Such comparison as can be made therefore indicates that systematics have not shared in this upward trend.

5.20 The question now arises of what, if anything, should be done. It is a question which has been asked before, between 1974 and 1977 when the Advisory Board for the Research Councils Review Group on Taxonomy considered the question of funding¹. They concluded rather coyly that taxonomy was not “over-supported” and that some areas “could benefit from a modest increase of funds” (p.41). Specific conclusions and recommendations which related to funding were:

- that ABRC should involve itself in the maintenance by DES of activities for which the NHM “has a primary responsibility and which cannot readily be done elsewhere” (Responsibility for NHM was not transferred to OAL until 1987);
- that Government departments and research councils should maintain their support for taxonomy;
- that special provision within the research councils was undesirable and that “continuously competitive appraisal” was to be preferred;
- that charging for taxonomic services was undesirable;
- that advantage be taken of international collaboration; and
- that developing countries’ access to United Kingdom taxonomic resources should be met from the ODA budget.

5.21 It is worth noting that while the Review Group looked for continued Government and research council support, it had no reason to suppose that such support would not be forthcoming. In particular, it made no provision for special arrangements within the research councils.

5.22 The evidence presented to our Committee, 15 years on, contained many suggestions for change—some of which went much further than the recommendations of the Review Group. Some witnesses looked to increased funding from external sources whether from industry, international agencies, foreign governments, or the European Community. Others looked more to institutional change at the Natural History Museum. Others continued to look to the Government and the research councils to provide a kind of “dual funding” for the institutions, with more assistance too from ODA. We now consider these suggestions in detail.

Industry

5.23 While there were instances where industry had funded research in systematic biology (NERC p.31), there was agreement in evidence that industry was unlikely to contribute to core funding. In general, industry was interested only in those areas which related to their own commercial interests (SOAFD p.85) and so its support was piecemeal, selective and not conducive to long-term stability (AFRC p.61; Manchester Museum p.137). As NERC acknowledged, it was

¹ *Taxonomy in Britain*, ABRC, 1977.

unlikely that “industrial demands for taxonomy will ever be adequate to maintain a core of research effort based on properly curated collections” (p.31). A possible exception was agriculture where the industry now bore “a very substantial part of the cost” of listing varieties of crops. ICI had contributed to the cost of the Vegetable Gene Bank, amongst other examples (MAFF Q 263).

5.24 A number of witnesses actually felt that it was unreasonable to expect industry to fund such long-term research (Fogg p.88; Ingram p.114; Round p.175). Some even doubted whether the full economic cost of the services provided by research institutions for industry could ever be recovered. The Royal Botanical Gardens thought that industry could pay commercial rates for the services it received (p.97) but others were much less sanguine and thought that was unrealistic (Fogg p.88). The Natural History Museum saw no prospect of materially increasing the £90,000 a year it received from industry by way of charges for services because so many of its inquiries currently come from other, non-commercial sources (Q 689).

Overseas Governments and International Agencies

5.25 The Committee received evidence that the United Kingdom already benefited from overseas patronage. US agencies commissioned research from United Kingdom institutions and funded research fellows at the Natural History Museum. The Botany Department, for example, currently has several posts funded by the US National Science Foundation. “A lot of money for systematic research is drawn in from overseas sources” (Blackmore Q 492). The Missouri Botanical Garden had also funded a full-time representative at the NHM (Stace Q 771). The Australian Biological Resources Study not only commissioned research but also had a resident botanic liaison officer at Kew (Q 594) as did India and South Africa. The Royal Society thought that the international scientific community should share “a degree of responsibility” for financing the collections because they were a major international asset (p.111). But witnesses poured cold water on the idea of other countries sharing the cost of maintaining United Kingdom collections. As Professor Ernst Mayr of Harvard wrote, “... any attempts to obtain such support would probably not get very far. Almost every other developed country faces the same problems” (p.141). Dr Werner Greuter, Director of Berlin Botanic Garden, was equally blunt in saying that “... Britain has no better claim for international support of its research than any other country of the world, and it can at the very best expect to get from international organisations the share of her own financial input” (p.91). CABI also thought it unrealistic to expect overseas help (p.45).

5.26 If prospects for additional assistance from foreign governments and institutions look bleak, what of international agencies? Evidence here was mixed. The UN agencies, on past experience, held out little prospect according to some (Anderson p.5; Bull p.31). The Royal Botanic Gardens considered that UN money should in any case primarily be spent in training personnel and curating herbaria in the developing world (p.97). The FAO had a scheme to support the maintenance and use of plant collections but its funds were “nowhere near adequate” to help the United Kingdom (Q 205).

5.27 But we heard of one newly established project which in the opinion of ODA could well offer “... a reasonable prospect of international monies being put into this area, so the question is the degree to which the United Kingdom will be able to win those monies” (ODA Q 146). This was the Global Environment Facility, managed by the World Bank but supervised by the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP) and set at 1.3 billion dollars for its pilot phase. The purpose of the Facility is to help developing countries to do that which they cannot normally afford in the fields of biodiversity, global warming and pollution of international waters. On our visit to the World Bank we were told that the United Kingdom Government had contributed £40m to the Facility. Science advice would be provided by an international Scientific and Technical Advisory Panel (the STAP). Many people to whom we spoke in the USA considered that the GEF had not been thought through and required more scientific input. Under the biological diversity element, ODA thought a “great deal more work could be funded in the area of taxonomy” (Q 146).

EC Funding

5.28 Very little support had, as yet, come from EC sources—possibly because systematic biology spans the competencies of so many Directorates General. Witnesses knew of no EC research programmes in systematic biology (NERC P.30; RBG Q 364 and P.95). Many, especially those associated with the institutions, were anxious that the EC develop more of a role in this area under the Framework Programme (Blackmore Q 499; Anderson p.5; Barlow p.9; Patterson p.165), though there is of course the possibility that any funds received from such a source would be

“attributed” to (ie partly set against) departmental budgets in respect of government funded organisations. The National Museum of Wales informed us that because of attribution they had been discouraged from making any application to the EC directly (Q 1104). Indeed the National Museum of Wales cited a recent instance where they had applied to the EC for a grant for fisheries research but had been told by the Welsh Office “that the Treasury had looked at this and we could obviously apply but we would lose pro rata of our grant-in-aid every pound that we were successful in gaining” (Q 1113).

5.29 The EC Commission wrote that “systematics must play a key role in any endeavour towards conservation of genetic resources and biodiversity. Therefore, we intend to support it through facilitating transnational and multidisciplinary collaborations”. It remains to be seen what this assistance will amount to in practical terms (EC Commission, p.244).

Natural History Museum

5.30 A large number of witnesses had doubts as to whether the Office of Arts and Libraries was the appropriate department to fund the Natural History Museum. The argument against OAL basically runs as follows. Since the transfer of responsibility from DES, the NHM is perceived to have suffered an erosion in its funding (Hawkes QQ 464—5). This is in part at least, attributed to the fact that OAL does not “understand” the Museum which, unique amongst the great institutions funded by that Office, has a major scientific mission to perform. As IPMS wrote “while the Minister for the Arts may state that his is an arm’s length relationship with those bodies for whom he is responsible, a pull on the purse strings can be felt a long way off and when it comes to funding decisions, a basic understanding of the scientific importance of the NHM is crucial” (p.125). The move to OAL had the effect also of highlighting “the potential rivalry, in financial terms at least, between the research and public display functions of the NHM” (Barlow p.9).

5.31 The Committee explored the question of scientific input into the funding process with the Head of the Office of Arts and Libraries and with the Natural History Museum who largely confirmed this picture. OAL told us that they relied “on the expert management of the museum to carry out consultation and advise us in the light of that what it thinks it needs to be doing in all the fields it is working in. This is presented in the corporate plan ...” (Q 34). The Office had, however, referred the 1990–95 Corporate Plan to the Chief Scientific Adviser and proposed to do the same with that for 1991–96 (Q 37). NHM confirmed that OAL “would not feel they were competent” to enter into scientific discussions (Q 630).

5.32 Witnesses’ views varied widely as to the implications of this. Some felt that funding of the NHM should revert to DES (British Ecological Society p.25; Davies p.65). Others considered that it was very difficult to tell in practice what would have happened to funding levels had responsibility lain with DES (OAL Q 48; NERC p.30) and that the question of funding agency was largely immaterial (Clarke p.53; Fogg p.88; Systematics Association p.187) so long as the special needs of the Museum were recognised (Institute of Biology p.121). Some, particularly those who were associated with the Museum directly, felt that they had actually fared better under OAL (Blackmore Q 502; Arme p.6; NHM Q 691).

5.33 But there were those who advanced more complicated solutions, like separating responsibility for research and curation from the exhibition/museum activities and transferring them to DES or ABRC (Nature p.275). This was vigorously opposed by both OAL and the NHM on the grounds that with funds coming from two sources, the Museum would fall between two stools. One department would play the Museum off against the other and it would end up “grossly disadvantaged” (QQ 648—651; 49).

5.34 One witness even proposed that in the event of inadequate support from the Government the responsibility for research and curation be entrusted to CABI (Barlow pp.11—12), a solution which CABI found impractical (Q 518).

“Dual Funding”

5.35 We received weighty evidence to the effect that, whatever resources might be obtained from elsewhere, the core funding of the major institutions engaged in systematic biology research should continue to come from Government sources and that specific research projects be funded through the research councils. The analogy was made with the so-called “dual funding” of University-based research by the Universities Funding Council and the research councils.

5.36 A clear exposition of this view was offered by NERC who wrote “With some exceptions, the beneficiary of such (systematic biology) research is usually society, rather than individual groups or

companies. It seems difficult, therefore, to identify significant potential sources of support other than through public funding. The question of how much funding is more problematic. It could perhaps be based on consideration of infrastructure and superstructure with some earmarking of funding to underpin systematic research at a standard which does not fall below certain minimum agreed critical levels. What this standard might be is a matter for discussion and international comparison, but at the least it should protect the important collections and their curation, and go some way to maintaining key centres of excellence for systematic research. Support over and above this level, for specific research activities, should be sought through normal responsive mode machinery and contract research" (p.31). AFRC agreed. The institutions required "secure funding" (AFRC p.61) while any extra money for research "should be available in a responsive way rather than directed towards a particular centre" (Krebs Q 210).

5.37 The Royal Society also gave a useful analogy of the way in which the major institutions in systematic biology research should be funded:

- the traditional curatorial function, ie acquiring, maintaining, and augmenting collections of samples and the library resources associated with their study (including floras, faunas and monographs) and taxonomy, including provision of information retrieval capability would be funded by core grant as at present;
- providing the scientific underpinning of disciplines such as chemotaxonomy, phylogeny and molecular systematics, and supporting researchers, for example in biodiversity or ecology, who need access to the collections and taxonomic services would fall to the research councils on a competitive basis and to customer government departments;
- industry should pay for curation services it required;
- while the public education/entertainment function should be met from core grant and self-finance (Royal Society p.112).

5.38 Individual scientists and the institutions themselves also looked to Government to provide core funding with a guarantee of continuity (RBG Kew p.197; Ingram p.113; NHM Q 685; Davies p.66).

5.39 We have already seen how witnesses regarded research council policy on systematic research. Witnesses expressed doubts as to whether the research councils would, without direction of some kind, provide additional support. They suggested ways in which research council funding for systematic biology research might be protected and enhanced. The most extreme solution put forward was the establishment of a separate research council for systematic biology research (Linnean Society p.134; CABI QQ 541—44; Manchester Museum p.137; RBG Kew p.95 and Q 328). Most of those who advanced this idea considered that other funding bodies should also be represented on the council. The Royal Botanic Gardens, Kew, for example, proposed "a Biodiversity Research Council with representatives from biodiversity institutes, universities, NGOs and other user groups ..." (RBG Kew p.95).

5.40 Such a mechanism had met with considerable success in Australia. The Director of the Australian National Parks and Wildlife Services described to us the work of the Australian Biological Resources Study which, in effect, operated as a systematic biology research council with funding of \$2.5m a year (about £1m). The study covers all systematic biology in Australia and applications are subject to peer review. Priorities are determined and varied on a rolling 3–5 year basis (Bridgewater QQ 592—4).

5.41 In Washington DC, the National Science Foundation told us that systematic biology research had always been a separate "line item" in their biological sciences program. Annual spending amounted to \$13.7m in FY 1990 and about 30 per cent of the 350 projects put up annually were funded. Total spending on systematic biology in both Australia and the United States is of course higher than is indicated by these funds, which are solely to ensure that the subject is kept at an appropriate level of activity. Without them, this could not be assured.

5.42 Other United Kingdom witnesses considered that a remedy lay within the existing research council structure. The Royal Society suggested that ABRC should consider how a systematic biology committee could be set up within the existing research council framework. Such a committee would pull together and give structure to existing funding (p.112; QQ 397, 403). Professor Lawton looked for "... some separate source of funding for that kind of activity that would be peer reviewed, but it would have to be on its own terms and not in competition with, let us call it, hypothesis-directed science" (QQ 785, 803—4; p.132). Many other witnesses favoured some kind of "earmarking" of funds by ABRC for systematic biology research (Hawkes p.131; Stace Q 758; Patterson Q 883; Anderson p.5; Panchen p.161; Systematics Association p.187). As

one witness wrote, "The idea of a special initiative to fund interdisciplinary work in systematics is worth considering to give the field a shot in the arm" (Patterson p.165).

5.43 Some witnesses recommended that such earmarked funds be entrusted to a particular research council—SERC (Bisby p.17) or NERC (Patterson Q 883). Indeed, the Royal Botanic Gardens Kew agreed that, as an alternative to their proposal for a Biodiversity Research Council, a special responsibility resting within NERC would be equally acceptable to them (Q 334). Some witnesses pressed for some additional funding for "earmarking" (Clarke p.53; Systematics Association p.187).

ODA

5.44 ODA's evidence to us laid great emphasis on sustainable development and biodiversity. In promoting these aims, systematic biology and taxonomy were considered to be vital tools. But ODA did not consider themselves to be responsible for any core funding of such research (p.44 and Q 128). Instead, they commissioned specific research projects in support of their aid activities which were demand led. Some examples of ODA commissioned studies in insect taxonomy or payment for identification services were cited as examples. Commissioned research is on a full economic costs basis and will include overheads (pp.45 and 46). Other witnesses spoke of ODA assistance to programmes in Indonesia (Bull p.31) and setting up a herbarium in Bangladesh (Heywood Q 851).

5.45 Many witnesses felt that ODA could do more to assist systematics. As one witness pointed out, ODA needed taxonomy but made no financial provision for it outside the limited in-house expertise at NRI (Disney p.71). Some witnesses thought that ODA should earmark funds for systematic biology research (Anderson p.5); fund specific projects at NHM (Barlow p.11); pay for staff at the NHM (Lawton Q 796); and train taxonomists for developing countries (Lawton Q 795). Professor Vernon Heywood told us that ODA was increasingly interested in supporting taxonomy, although until recently it had been discouraged from doing so on policy grounds (QQ 851—4).

5.46 In the United States, the National Science Foundation and the Agency for International Development (AID) had set up a joint fund to finance biodiversity research with a total commitment for 1991 and 1992 of \$7.2m, \$2.5m of which came out of the USAID budget.

COMMITTEE OPINION

Core Funding

5.47 We conclude that there is no viable alternative to Government core funding of systematic biology research—that is to say to their providing reasonably well assured moneys on which future plans can securely be made for the current major national collections in museums and gardens (the institutions) and for the research associated with maintaining and developing those collections. Evidence makes it clear that neither industry, nor overseas governments, nor international agencies, nor at present the EC, nor ODA, can be looked to for core funding. Private benefaction on the scale required has not been attracted to systematics.

5.48 Core funding for scientific activities has clearly been under severe pressure at a number of institutions—particularly at RGB Kew and at NHM, though less so at RBG Edinburgh—and this was confirmed by our survey (para 5.15). The increases in funding have been less than inflation so that in real terms funding has declined. Such has been the attrition that there can be little scope for further efficiency gains—hence the recent diminution in staff and changes in curation policy. There is evidence to suggest that further cuts would be insupportable and lead to a major imbalance between the inestimable scientific value of the United Kingdom collections on the one hand and our ability to use them and benefit from them on the other. For the future, therefore, we recommend that funding for systematic biology research associated with the curation of the national collections should be maintained in real terms.

5.49 We consider that arguments as to which department of state should fund the institutions to be irrelevant to the debate on the level of funding, provided that those departments have access to science advice in appraising those institutions' needs as expressed in their corporate plans. While it is impossible to say whether or not the NHM would have fared—or would in the future fare—any better under DES than it has under OAL, there is scope for improving the science advice available to OAL. Unlike other museums funded by OAL, NHM undertakes major scientific activities and this needs to be recognised in the funding process. OAL clearly has no in-house capability of assessing NHM's funding requirements for science and its outside consultations appear to have been rather inconsistent. We therefore recommend that OAL should establish an expert scientific panel to advise them on the NHM's scientific requirements, as expressed in the corporate plans they

annually submit. In appointing the panel, OAL should take the advice of ABRC which performs a comparable role for DES in respect of the annual bids from the research councils. Such a panel might also be consulted on the annual spending bids of any other natural history institution receiving grant-in-aid, whatever the parent department.

EC Funding

5.50 There is clearly scope for systematic biology research to figure more prominently in a future Framework Programme. United Kingdom scientists and institutions would be well placed to apply for funds. We recommend that the Cabinet Office and research councils press for the inclusion of more systematic research in the next EC Framework. But given current Treasury practice relating to additionality and attribution of EC research spending and given that so much systematic biology research in the United Kingdom is conducted by grant aided institutions, some relaxation of Treasury rules would be required to guarantee some element of additionality. Otherwise, United Kingdom systematic biology research would be severely disadvantaged.

Overseas Funding

5.51 It is unrealistic to expect assistance from overseas governments for systematic biology research or for maintenance of the collections, though the presence in United Kingdom institutions of overseas scientists—frequently funded by their respective governments—is very much to be welcomed.

5.52 The United Kingdom is well placed however to benefit from any systematic work accruing from any major environmental initiative, like the Global Environment Facility. But it is our clear impression that United Kingdom scientists and institutions can be associated with GEF projects only if they are involved in presenting developing countries' proposals or if they interest themselves in the assessment and contract process. We therefore recommend that United Kingdom systematists and institutions maintain close contact with the GEF office at the World Bank and with the United Kingdom representatives on the facility's science advisory committee (the STAP). Furthermore we are not entirely convinced that the STAP will, unaided, be able to guarantee that GEF biodiversity projects will be funded on firm scientific advice. Much will depend on World Bank procedures and their readiness to insist that projects be supported by scientific data and subject to review by acknowledged experts in the field. We therefore recommend that in view of the size of the United Kingdom's financial contribution to GEF and of the scientific resources available in this country, the Government should monitor very closely the way in which GEF funds are disbursed. Such monitoring might require the expert scientific assistance of a learned society.

"Dual Funding"

5.53 It is apparent from the evidence that systematic biology research has not fared well under the research council system. This is because, like the essential but unglamorous subject of thermodynamics in physical science, it lacks the appeal of other parts of biology—for which it is nevertheless a necessary complement. There are no grounds for supposing that circumstances will improve—any more than they did after the ABRC review of 1976—unless some special recognition of systematic research is made in research councils' funding.

5.54 We note the steps taken in Australia and in the United States in this connection. We do not agree with those witnesses who wish to see the establishment of a separate research council for systematic biology. But we consider that some degree of earmarking of funds for a limited period of five years is desirable. We therefore recommend that ABRC, using its powers to protect subjects which fall between the research councils' responsibilities, make provision of £1m per annum exclusively for systematic biology research beyond the routine research activity associated with maintaining and updating the systematic collections. This sum would be administered by a single research council, or a consortium of research councils, or by ABRC itself using its new executive powers.

5.55 While NHM may apply for research council support there appears to be confusion amongst other publicly funded institutions with excellent scientific reputations as to whether they may apply for research council funding and, if they apply, whether the research councils will consider them eligible. In our opinion they should. We therefore recommend that ABRC make a statement declaring that the grant-in-aid institutions be eligible for research council grants for research in systematic biology.

ODA

5.56 In pursuance of its support for biodiversity ODA should ensure that United Kingdom systematics in the key areas for which it is a customer is kept in good heart. We therefore recommend that aid projects dependent upon systematics should as a general rule include funding for a United Kingdom based research project at one of the major institutions, with appropriate overheads.

CHAPTER 6 PROBLEMS OF CURATING THE COLLECTIONS

6.1 In chapter 2, we showed that systematic biology research depended heavily upon collections of specimens. In chapter 4 we identified the principal centres of research, including those institutions which housed major collections of taxonomic material. We now look more closely at some of the collections about which we have received evidence, and in particular at the difficulties they are now encountering which impede research.

Importance of the Collections

6.2 Practically every witness stressed the importance of collections to systematic biology research and the particular importance of the United Kingdom's major institutions at international level. The collections are important because (CABI p.42):

- they preserve "type" material, the specimens to which scientific names are permanently linked. These are the irreplaceable basis of biological nomenclature and essential in determining the names to be applied;
- they are necessary to verify published research on particular organisms. Such research which cannot be so verified is of limited value;
- they are a database of the geographical distribution, range and seasonality of species. Years and dates of collection can be used to monitor changes in distribution;
- they provide an important source for taxonomic research and enable the variation in and the limits between species to be determined;
- as new techniques are developed for characterising species, type collections offer the only means of verifying the presence of newly recognised features in the specimen on which a species was based.

6.3 Thus we were told that "well curated reference collections are a basic resource for good systematic biology research" (NERC p.25); that collections were "fundamental to conducting accurate and useful systematics" (ODA p.45); that they were "vital and fundamental" (Linnean Society p.144); and that, quite simply, "Systematic biology is a collection-based science" (Systematics Association p.187).

6.4 The United Kingdom collections, it was claimed, are particularly important because of their enormous international coverage, their age, and their size. As NERC said, "British workers were active in the late 18th and early 19th centuries and established important type collections at that time. Collections from the countries of the former British Empire are particularly important, being unique and irreplaceable. Collections held at British institutions such as the NHM and RBG are exceptionally important in world terms" (NERC p.49).

6.5 Witnesses considered that ownership of these collections brought a moral and scientific obligation to maintain them, to render them accessible to national and overseas visitors, and to carry out research on them. As the Royal Society told us, the collections gave the United Kingdom "unique opportunities, but also unique responsibilities and a unique burden ..." (Royal Society p.111). Time and again witnesses echoed these dual themes of the importance of the collections on the one hand matched by a deep sense of obligation to maintain them on the other—individual scientists, overseas scientists, technical staff, learned societies, research councils, institutions, university departments, even industry. (Lawton Q 793 and p.132; Anderson p.4; Bisby p.16; Bourne p.20; Burley p.32; Cain p.47; Davies p.66; Pettit p.82; Fogg p.87; Jury p.128; Panchen p.161; Patterson p.163; Walters p.196; Whittington p.197; Baas p.7; Bridgewater p.21; Greuter p.92; Hallé p.93; Mayr p.141; Raven P. ; Smithsonian P. ; IPMS p.123; Linnean Society p.133; Systematics Association p.187; British Ecological Society p.24; Polychaete Society p.169; Royal Horticultural Society p.177; University of Edinburgh p.192; RBG Edinburgh p.110; Natural History Museum p.155; Manchester Museum p.134; National Museums of Scotland p.148; Unilever p.189; SmithKline Beecham p.184; William Halcrow and Partners p.253.)

Financial Straits

6.6 Fulfilling obligations—even moral ones—does not come cheaply especially where buildings, maintenance, and intellectual endeavour are all involved. We received plenty of evidence indicating that curation of many of the collections was encountering major financial problems. But the picture was far from uniform.

6.7 Of the *national institutions* the NHM featured most prominently. We have already shown in chapter 5 how the decline in grant-in-aid over the last decade had led to the staff cuts announced in the 1990–95 Corporate Plan. These cuts affected curation as well as research. In the Corporate Plan the Museum announced a strategy for curation of “continuing a basic level of care and maintenance of the collections ... making these materials available to research workers worldwide ... developing those parts of the collections that are relevant to the Museum’s research programmes ... providing an effective and efficient advisory service” (OAL pp.8–9). This admitted that while all collections would receive “care and maintenance”, only some—in view of staff losses—would be under the care of scientific staff actually engaged in doing research on those collections.

6.8 Thus many witnesses who had hitherto viewed the curation of the NHM’s collections with admiration now became alarmed. CABI thought curation was now “probably less than adequate”; the Linnean Society complained that some collections were now under care and maintenance only following “swingeing cuts” (p.134 and Q 425) and this was echoed by others (Hewitt p.96; Bridgewater p.21; Royal Society of Hygiene and Tropical Medicine p.179; Royal Horticultural Society p.177; Palaeontological Society p.159; Institute of Biology p.121). The NHM itself admitted to us that they have “serious storage and curatorial problems which can only be solved by major investment” (Natural History Museum p.155).

6.9 Witnesses pointed out how specialists were being lost and not replaced. In some cases their work was not replicated elsewhere and the loss was thus permanent and, in a sense, of national significance (NMW QQ 1146–9). Thus the loss of the NHM diatom section was lamented by the Linnean Society (p.128), though we were assured by another witness that the number of staff working on diatoms had actually risen and that they were using new molecular techniques (Blackmore Q 485).

6.10 The other institutions in receipt of grant-in-aid showed similar signs of strain and these affected curation as much as research (see chapter 5 and Liverpool Museum Q 1093; RBG Kew pp.93 and 96).

6.11 The institutions’ concern was shared by the Agricultural and Food Research Council who complained, “We do feel a little insecure about the funding of our own collections at the moment ... We would like to see some longer term security of the funding and I think that has to be looked at centrally” (Q 205). At the same time, however, AFRC, recognising no doubt that some discrimination was called for in the level of expenditure on curation as opposed to other aspects of systematics, urged that “Care is needed that reference collections do not swallow up scarce resources which may be better deployed elsewhere” (AFRC p.60).

6.12 But the problems of the institutions and AFRC were as nothing compared with the fate of *university systematics collections*. These suffered when the departments which used the collections closed or changed their character. They had also suffered in consequence of UFC funding criteria which value teaching and research higher than the long term maintenance of a resource like a systematics collection. Fortunately UFC, following its Earth Sciences Review, had centralised geology collections into five centres with capital investment and long-term staffing. Manchester Museum, for example, had been given an earmarked grant to maintain two keepers and additional staff in the geology department (Q 1077). But even where departments remained open, systematics collections were often no longer considered “relevant”. RBG Kew complained that “University reference collections are at the whim of the current head of department who may have no sympathy with systematics—we have seen again and again the disbanding of collections” (p.96; see also Stace p.195). Prof. Heywood thought that “Culture collections in universities are particularly vulnerable. Likewise living collections in university botanic gardens are increasingly at risk as universities, mistakenly I believe, regard them as dispensable luxuries” (p.99; see also NCCPG p.144 on the threatened collections at the botanic gardens of the universities of Hull and London).

6.13 Thus we were told how Liverpool and Birmingham herbaria had been “banished” and how “the very rich collections at Cambridge, Leicester and Reading could very easily become victims in a similar way before the end of the decade” (Smith and Stace p.195). The University of Newcastle Upon Tyne’s Hancock Museum complained that the University, in the words of their own

Planning and Resources Committee, considered that the Museum had "little direct relevance to the academic activity of the University" (Hancock Museum p.316).

6.14 There appeared to be no organised way of rescuing university collections in distress. The International Mycological Institute had been asked from time to time to take over endangered scientifically important collections from United Kingdom universities and other institutions. In 1990–91 they rescued the Aquatic Phycomycete Culture Collection from the University of Reading. IMI expect further reports of this kind in the coming decade (CABI p.42). The Royal Horticultural Society and the NCCPG had on occasion performed similar roles with living collections (NCCPG p.144). This bilateral rationalisation with an orphan collection being received in a host museum appeared typical. NERC told us how they had on occasion given grants to university staff to re-work collections held by university and local museums into a form appropriate for depositing with a major national institution. The cataloguing of the marine isopod and tanaid collections held at Nottingham University were cited as an example (p.29).

6.15 The situation at *local authority museums* was perhaps slightly less dire, revealing a picture of gentle decay rather than abrupt extinction. CABI thought that "The plight of many United Kingdom provincial museum collections is particularly worrying in a national context" (p.43), a sentiment echoed by the National Museum of Wales (Q 1104 and p.151), the Liverpool Museum (Greenwood p.90), and the NHM (p.155). The collections had suffered from attrition over a period of years. As one witness cogently put it to us, "Local authority museums neglected systematic collections and did not attract staff of high standing in the academic world to speak for this subject. When responding during recent decades to the popular concern with the natural environment, curatorial effort was diverted to biological recording and protection, to good effect in these fields, but to the neglect of the collections as a resource for the world-wide research community. Changes in local government are increasing the conflict between the long term requirements of systematic biology and the immediate services to local charge payers" (Pettit p.81).

6.16 Our attention was drawn to a five hundred page survey of provincial museum collections which confirmed these fears¹. It found that of 254 institutions surveyed,

- 80 per cent reported collections lost through neglect, bad curation and disasters;
- 190 museums had natural history collections with no full-time curatorial staff;
- only 13 museums had more than three natural history staff;
- only 33 museums had technical staff in natural history;
- reference works and microscopes were in short supply.

6.17 To meet these problems the author recommended that

- Area Museum Councils should appoint peripatetic biology curators to help with the care of, and if necessary to curate biological collections;
- major museums should act as parent museums to the peripatetic curators and give a home where necessary to important collections in need;
- parent museums should receive additional facilities;
- the extra funding necessary should be obtained through the MGC and ultimately OAL; and
- the Museums Association, the Museums and Galleries Commission and the Research Councils should establish a steering group to monitor action on these recommendations.

6.18 Notwithstanding the study by the Museums Association, evidence indicated that some steps had been taken in connection with provincial collections. The Museums and Galleries Commission (MGC) had provided limited funds in support of natural history collections (except the grant-aided institutions) called the Natural History Incentive Fund. The money was channelled through Area Museums Councils but the amounts were small in comparison with sums available for arts collections (Pettit p.81; Greenwood p.90).

6.19 The responses to our survey showed that in spite of the complaints we received in evidence, expenditure on curation had in fact held up quite well between 1980 and 1990. Our figures show that total expenditure rose from £6.5 million to £8.0 million (Table 6.1). Museums and gardens both spent more in 1990 than they did in 1980. Manpower was roughly constant, rising from 319 to 324 man years (Table 6.2). If we look more closely at the more important collections, we find

¹ *Biological Collections United Kingdom*, B. Williams, The Museums Association, 1987, pp.vii–ix.

that curatorial effort, as measured in man years, at national museums remained about the same (156 in 1990 as opposed to 152 in 1980) while effort at national gardens rose (from 79 to 87).

TABLE 6.1

Total Expenditure By Activity

Activity	£m (1990 prices)			% Total Expenditure		
	1980	1985	1990	1980	1985	1990
Research	17.5	16.3	16.5	59	57	54
Curation	6.5	6.5	8.0	22	23	26
Information Services	3.5	3.5	3.8	12	12	12
Other	2.3	2.3	2.4	8	8	8
Total Expenditure	29.9	28.6	30.6			

TABLE 6.2

Manpower Engaged in Systematic Biology by Category of Activity Performed

Activity	Manpower (MnYrs)			% Total Manpower		
	1980	1985	1990	1980	1985	1990
Research	552	547	514	49	50	47
Curation	319	306	324	28	28	30
Information Services	132	124	131	12	11	12
Other	123	125	127	11	11	12
Total Manpower (MnYrs)	1125	1101	1096			

6.20 This contrasts with the decline in research funding and manpower which we described in chapter 5 and seems to indicate that research has been cut back in preference to curation. This inference is supported by evidence from the NHM which showed that curatorial staff have remained in long term employment while research staff have increasingly been employed on fixed term contracts in recent years (NHM p.168). These figures, however, exclude the effects of the most recent developments at the NHM.

6.21 A number of solutions to these funding difficulties were put forward by witnesses. The first, and for the government probably the most costly, is that core funding of the major national grant-in-aided institutions for curation as well as research should henceforward be protected in real terms. For collections outside the national institutions, Manchester Museum considered the resources hitherto granted by NERC and MGC to reorganisation and support respectively were unequal to the task ahead. Manchester Museum recommended a funded joint initiative by NERC and MGC to calculate the staffing and funding necessary for each collection to achieve high standards, within the global sum available for curation of systematics collections (pp.136–7). AFRC thought that the funding of collections should be coordinated centrally and that they should be institutionalised close to the research base. AFRC thought that DES had a role to play (Q 205).

6.22 Witnesses also looked enviously overseas—particularly to the United States and Australia (Manchester Museum pp.137–8; RBG Kew p.98). We learned at first hand during our visit of the provision made in the USA. The National Science Foundation—in addition to the support for research which we described in chapter 5—maintains a Biological Research Resources Program. This was set up in 1972 to support curation and the rationalisation of collections. Its budget is \$6.4m for FY 1990–91, and grants are awarded mainly on a rolling basis and subject to the views of external referees of the recipients' commitment to research. In Australia, the ABRs has also devoted considerable sums to collection management and improvements within institutions (Bridgewater p.21).

Accessibility and Repatriation

6.23 There was some discussion in evidence of the possibility of sending some of the United Kingdom collections back to the countries of origin so that they could look after them themselves. The Royal Society considered that one way of sharing the burden of curation with the international scientific community “would be to dispose of some holdings for example by relocating specific collections via long-term loan to relevant user groups in other countries ...” (Royal Society p.111).

6.24 Australian scientists argued that if maintenance and accessibility of United Kingdom collections of Australian material were to be permanently impaired then they should be returned. As Prof. Ride wrote, “... the return of the collections to where they would be used would be the preferred option. Curatorial facilities in Australian national collections are certainly the equal of those in Britain and the international community need have no fear for maintenance or access. If there is any possibility that the diminution of effort in Britain is to be a permanent arrangement, and the international role no longer fully supportable by ongoing participation, the Committee might well consider that Britain’s obligations to science might be served by relocation in countries which could guarantee satisfactory performance” (Ride p.296; Bridgewater Q 595–6). RBG Kew on the other hand cited evidence (RBG Kew p.98) published in *Nature* where three Australian botanists agreed that “taxonomists might usefully dispense with existing massive herbarium collections”.

6.25 There were also great advantages in retaining the integrity of the United Kingdom’s collections because their international character gave a unique opportunity for international comparisons. Therefore the argument for repatriation was very much one of last resort. (Bridgewater Q 597).

6.26 Furthermore many of the countries of origin were developing countries with limited resources, and many examples could be cited of the loss due to civil strife or neglect of “base collections containing irreplaceable material” (ODA p.45). For most areas of what formerly constituted the British Empire repatriation was simply not an option (Systematics Association p.187).

Care and Maintenance v. Research

6.27 So far, we have made no mention of what constitutes good curation of a systematics collection. Yet this question frequently came up in evidence and is central to a satisfactory resolution of the current problems besetting systematic biology research and its resources.

6.28 We referred earlier to the NHM’s admission that certain of its collections would in future receive care and maintenance only so as to enable research resources to be focused in priority areas set out in the Corporate Plan. And we saw too how exiguous had become the staffing position at non-national collections so that even where care and maintenance was offered research was rarely conducted (see also Hancock Museum p.316).

6.29 Most witnesses took exception to the idea that care and maintenance was enough. “Just maintenance—keeping the alcohol bottles topped up and that sort of thing—is not enough. You have to have active researchers curating collections as well: people who have become experts in their own field” (Linnean Society Q 460). This view was typical (Systematics Association p.187; Stace Q 770; Lawton Q 793; Patterson p.161; Round p.173; NMW and NMS Q 1126). It was also impressed upon us by the leading US systematists whom we met at the Round Table held for us at the Smithsonian Institution.

6.30 There were two reasons for this assertion. First, only a trained systematist could understand “what the collections are, what is needed, how they should be ordered and arranged, what sort of scientific work is concerned with them ...” (Linnean Society Q 470). Secondly, only by exposing the collections to research could they be developed intellectually. Research bestowed on collections the added intellectual value without which they became moribund. In the words of RBG Edinburgh “... good curation is not simply the preservation of what exists but the enhancement of its value through research” (p.110).

6.31 There was however a contrary view. Dr Bridgewater asserted that “Taxonomists will almost always maintain that you have to have someone to do research in order to maintain the collections properly. That is not true in my view. It certainly helps and makes for a live institution—certainly the picture I described of just collections being properly curated would make for a rather non-vibrant community, but that would only be the case if foreign scientists did not continue to come and work along with what I am sure would always be a minimal level of input from the United Kingdom.” (Q 601).

Training and Professionalism

6.32 We were made aware of two problems here. The first was the decline in the technical training of technicians (preparators) capable of the proper care and maintenance of collections as collection managers. In the United Kingdom, these had traditionally been trained through apprenticeship. But this system had now died out and the surviving products of the system are now in their 50s. This contrasted with Germany where formal three year courses produced preparators in zoology, geology and medicine technologies (Horie pp.100–1). Meanwhile in the United States a programme of training for conservation and collection management was being initiated by the Institute of Museum Services (Manchester Museum p.138). But in the United Kingdom there was a shortage of trained (non-graduate) curators (Greenwood Q 1090).

6.33 A second consideration concerned the status of technical staff engaged in care and maintenance curation. As we observed in para 5.3 above the NHM Corporate Plan 1990–95 announced a new management structure for curation. This involves “a closer definition of posts and the management structure within the areas of curation and research. Associated with those changes will be the extension of fixed grading for some posts” (OAL p.11). Some complain that this policy will have the effect of creating artificial and dispiriting barriers between technical curatorial staff on the one hand and scientific staff on the other (Panchen p.16). Others consider that the distinction is to be welcomed on the grounds that it will reduce research work of indifferent quality, at least at NHM (Barlow p.11). The National Museum of Wales, by contrast, does not make such a firm distinction.

6.34 Many witnesses urged that, however staff may be graded, it was essential for all curatorial staff to feel that they were part of a team. This was impressed upon us strongly during our visit to the United States, which has long experience of such distinctions. Mr Greenwood of Liverpool Museum told us that “You have to have a link between your curation and research. The way that we do that is to have small units associated with collections where more senior staff will do research, or more research, and the more junior staff will be doing the curatorial work, the basic work, so that there is a team effort here and it is seen to be a team where all the elements of it can see that they have a responsibility to the totality” (Q 1086). Continuing education carried out within the institution was also thought to be helpful both to non-scientific curatorial staff and outsiders on payment of a fee. Such education might enable curatorial staff to transfer to systematic work in the course of time (Barlow p.11).

Co-ordination

6.35 There is already some element of division of labour of curating the reference collections of higher plants in major United Kingdom institutions and it centres around the Morton Agreement which dates from 1961, entered into by RBG Kew and the British Museum (Natural History) as it then was. Thus collections and research are divided both systematically (eg fungi and ferns at Kew and mosses, liverworts and algae at NHM) and geographically (eg Europe, North and Central America at NHM, South America and Africa at Kew). The transfers which were effected at the time of the Agreement are now considered irreversible (Prance Q 362–3). The keepers of the herbaria of Kew, Edinburgh and the NHM met annually to ensure a united policy (RBG Kew p.94 and Q 360) and this was considered useful (Fogg p.87). The Committee note with some surprise that, in spite of the close co-operation under the annual discussions, Kew were not consulted on the implications of the NHM Corporate Plan, though it clearly had implications for the collections transferred under the Morton Agreement (Q 361).

6.36 But there were those who felt that the Morton agreement should be re-examined. Professor Fogg thought that the Agreement now had “little rational basis” though it served as a useful framework (p.87). CABI went further. They found the separation of mycological collections between their own IMI and Kew and NHM tiresome. Although complementary the boundaries were systematically illogical and standards of curation varied. There was also perceived merit in including CABI and regional museums within its scope. Indeed an expanded Morton-type agreement to rationalise United Kingdom systematic collections was urgent in view of the plight of many provincial museum collections (CABI p.43). Prof Prance of Kew thought that there was a need for greater coordination between institutes both within the United Kingdom and more particularly the EC. Like the Morton Agreement this coordination would be based on both regional and systematic lines (p.94).

6.37 Some international specialisation already occurred at an informal level. When we were in the United States we were told by the Systematic Entomology Laboratory of the Department of Agriculture (which also runs the Smithsonian entomological collection) that they specialised in

New World entomology and left the old world and Africa to CABI and the NHM. There was also some evidence to suggest that a degree of specialisation already occurred in Europe in that the national collections of former colonial powers tended to follow the boundaries of empire. "For almost any group of organisms either some particular British, German, Russian or United States museum is the leading receptacle" (Mayr p.141).

6.38 Other countries already had a forum in which a national policy could be formulated. Prof Dr Baas of Leyden wrote to us about the cooperation which existed in the Netherlands "between all systematic subdisciplines, university departments, and systematic research institutes. We are currently engaged in drafting a National Plan for Systematics and Evolutionary Biology in which the various projects and specialisations will be prioritised" (Baas p.7). In Australia, the ABRS performed this function (Bridgewater p.21).

COMMITTEE OPINION

A Unique Resource

6.39 We were convinced by witnesses from both home and abroad that the major United Kingdom institutions hold systematics collections which are unique and of inestimable value to world science. We saw this for ourselves when we visited RBG Kew and the NHM. For example, the NHM holds specimens and drawings which were brought back from the expeditions of Captain Cook and Charles Darwin, and which are still of scientific value. They, of course, are only a small fraction of the holdings.

6.40 We further consider that collections are indispensable to systematic biology research—including research on issues like biodiversity for the investigation and preservation of which systematic biology is essential. These collections should therefore be properly maintained so that they remain accessible to United Kingdom and overseas researchers alike.

Funding

6.41 It is clear from the evidence and from our own survey that all the collections have encountered financial problems, the national collections rather less than the university and provincial holdings. And evidence is clear that this is beginning to affect the quality of curation and accessibility of the collections. At the same time resources are not unlimited. In comparison with some other science facilities which have come to our notice this year, major systematics collections survive in reasonable shape, at least in the short term. And we also take to heart the advice of AFRC that the collections should "not swallow up scarce resources which may be better deployed elsewhere" (see para 6.11 above).

6.42 For the national collections, we recommend that core funding be maintained in real terms at such levels as to ensure the long term well being of the holdings. This expenditure shall include care and maintenance of the collection and (as we have already recommended in para 5.47–48) such research as is consistent with the preservation of the integrity of the collection as a scientific resource.

6.43 We are rather more exercised by the fate of collections which lie outside our major institutions, at university museums and provincial museums. We were impressed by the provision made by UFC to rescue geology collections endangered by closure of departments resulting from the Earth Sciences Review. With extra funding for capital investment and staffing, these collections were centralised at five centres. We would hope that UFC would extend the same treatment to other systematics collections affected by university reorganisation in the future.

6.44 In any case, the welfare of collections cannot always wait for this kind of assistance. And assistance of the kind occasionally available from NERC for bilateral amalgamations seems to us to be unequal to the task of stabilising those collections which are important and bringing them to those centres of research where they will be worked on.

6.45 We think that there is a good case for a new fund for sustaining the physical state of important biological collections on the lines of the US National Science Foundation's Biological Research Resources Program. We therefore recommend the establishment in the United Kingdom of a Biological Collections Fund to be administered by the Office of Arts and Libraries through the Museums and Galleries Commission. The fund should "roll" and grants should not become recurrent. Criteria for award should favour permanent solutions where practicable and take into account the availability of the applicant collections for research. The fund might amount to £0.5m per annum in the first instance. Applications for assistance should be considered by a committee of

award drawn from the forum of systematics collections as recommended in para 6.55 below. Only those institutions not in receipt of grant-in-aid may apply, except in respect of schemes for incorporating a collection into that of a grant aided institution.

Accessibility and Repatriation

6.46 Biological collections with only a few exceptions have belonged only to the collectors and the institutions which house them. They have for the most part no intrinsic worth, though some items acquire a rarity value—like a unique fossil specimen of *Archaeopteryx*. Otherwise—unlike the objects in art galleries—their worth lies in the intellectual added value with which they have been endowed by research and curatorial processes at the holding institution and their accessibility to scientists for a very wide range of purposes.

6.47 But there is a persuasive scientific argument that collections should be located where they will (a) be well maintained and accessible; (b) be exposed to research and (c) form part of an international resource. The current location of overseas material in the United Kingdom ensures that they are part of an international resource with all the attendant advantages to science. We acknowledge that should there ever be evidence that an important collection is being badly maintained, becoming inaccessible, or not being exposed to research of any kind, there is a scientific case for sending them on extended or permanent loan to centres where they will be worked upon and well cared for—either in the country of origin or elsewhere.

6.48 We do not think that our leading systematics collections have as yet reached that stage but, unless the new curatorial policies of such institutions as the NHM can be seen to work over the next few years, it may not be far off.

Curation

6.49 There can be no doubt that, ideally, collections should ultimately fall under the care of a staff member who is given the opportunity to take an active research interest in the field and who will know to whom to turn for expertise beyond his own immediate ken. Unless a collection is exposed to research activity—preferably on an in-house basis—its utility will diminish because designation and arrangement of the material will not reflect the latest research.

6.50 We agree with those witnesses who maintained that visits from researchers from other institutions or overseas are no substitute for regular in-house research. At second best, there may be scope for appointing honorary curators from other institutions within the United Kingdom who are able to give regular and sustained attention. And regular visitors from overseas might be willing to undertake similar responsibilities. Suitable financial arrangements could be made in respect of work done.

6.51 Accordingly we recommend that no important collection be left without regular, though not necessarily continual, attention from a researcher or scientific officer who is contracted so to do.

6.52 However it is inevitable that much routine care will fall on technicians and their skills must be maintained at the requisite levels by in-house training and/or other means. They should be perceived by all concerned as part of a research team which is advancing systematic knowledge as a product of their collective activity. Technicians should be encouraged to keep abreast of, and indeed themselves develop, modern curatorial skills.

Co-ordination

6.53 There is a strong case for strengthening co-operation between custodians of systematics collections. We were surprised to find that annual discussions under the Morton Agreement between RBG Kew and the NHM included only RBG Edinburgh from amongst the non-contracting parties. And we were very surprised to find that there had been no consultation between NHM and Kew on the curatorial consequences on collections transferred under the Morton Agreement of the NHM's 1990–95 Corporate Plan. By contrast, we were favourably impressed by the Dutch idea of a National Plan for Systematics and Evolutionary Biology.

6.54 We conclude that there is a case for strengthening co-operation between institutions holding systematics collections by the creation of a new forum in which they would be represented. This would help to ensure that an institution would take the wider implications of its management decisions into account before it actually took them. It would also be a forum in which some kind of national curatorial policy might be worked out so as to guarantee appropriate coverage of

specialities in appointments at United Kingdom, rather than single institution, level. These institutions are ultimately paid for by taxpayers. Taxpayers have every right to expect that they talk to one another sensibly. Such a forum would also have the added advantage of placing the United Kingdom in a stronger position to participate in discussions on international aspects of collections policy.

6.55 We therefore recommend that the annual talks between the parties to the Morton Agreement be replaced by broader based discussions involving NHM, RBG Kew, RBG Edinburgh, the national museums, CABI, and leading university museums to rationalise holdings, staff appointments and areas of specialisation. This new body should have its own terms of reference and an independent chairman appointed by the Royal Society. A committee of award drawn from this forum would also advise OAL on applications to the proposed Biological Collections Fund (see para 6.45 above).

CHAPTER 7 COLLAPSE OF SYSTEMATIC BIOLOGY AT THE UNIVERSITIES

7.1 When we considered research funding we found that its decline was in some measure due to a contraction in systematic biology as a subject at British universities. When we looked at curation we found that a symptom of this contraction was that university systematics collections had been imperilled. We now examine more closely the extent to which the subject has fallen on hard times and why; and the effect of this on the training of future systematists.

Systematics at school

7.2 Even before university, the subject received scant attention. We were told that the teaching of systematics had declined to a very low level in school courses. DES informed us that systematic biology formed a part of the National Curriculum at all four key stages of education for pupils from 5 to 16 in connection with attainment target 2, "Life and living processes". But these attainment targets have 18 "strands", only two of which have a systematic element (DES, p.245). At Advanced Level, syllabuses are set by examining boards and the attention paid to systematics varies.

7.3 In the view of practising systematists, the teaching of systematics had declined to a very low level in school courses. So far as they were concerned, hardly any coverage was given to systematics in biology GCSE courses, even in connection with the diversity of organisms. It could "no longer be assumed that students entering higher education have any understanding of the subject" (Systematics Association p.188; see also Beverton p.237; Bolton Museum p.239).

7.4 The Royal Society wanted more stimulation of "the initial interest of sixth-formers and undergraduates in natural history, taxonomy and systematic biology" (Royal Society p.113). The task will not be easy. We noted, from their sixth form course guide, that a major public school near one of our more ancient university towns took the view that "taxonomy and adaptation of animals ... have always been the less exciting aspects of traditional biology courses and can now be omitted". As a result it no longer offers those options.

Undergraduate teaching at universities

7.5 The almost universally held view of witnesses was that university teaching of systematic biology was no longer adequate (British Ecological Society p.25; Clarke p.53; Hewitt p.97; Heywood p.99; Edinburgh p.114; IPMS p.125; Lawton p.133; Manchester Museum p.137; NHM p.157; Patterson p.165; Smith p.193). Witnesses spoke variously of the subject as being in "very severe" decline (European Garden Flora Project p.75); "almost extinct" at undergraduate level (Fogg p.88); and "virtually non-existent" (Round p.175).

7.6 Only at very few universities (Oxford, Reading and Aberdeen) were distinct courses taught in systematic biology or taxonomy (Burley p.33). Oxford was considered unusual in making taxonomy compulsory (Krebs Q 213). The Linnean Society have identified that of the 63 university and polytechnic biology departments, 65 per cent had no systematics teaching at foundation level, and 61 per cent had none at advanced level. Only 8 per cent had it as a substantial component at foundation level. 21 per cent of departments' courses had a substantial advanced level component but only 9.5 per cent (ie 6) had courses designed primarily to teach the principles and practice of systematics (*Systematic Biology and Taxonomy in Higher Education in the United Kingdom*, M F Claridge and M Ingrouille, Linnean Society, December 1991). The Linnean Society survey also showed how sparse and isolated systematists had become in universities and polytechnics. Out of 1061 biological academic staff surveyed, only 5.6 per cent regarded themselves as systematists with

a further 4.1 per cent who regarded themselves as partly systematists. Our own survey showed that the proportion of undergraduate time devoted to systematic biology at those universities and polytechnics that taught some element of systematics had declined from 17.1 per cent in 1980 to 8.9 per cent in 1990 (Table 7.1).

TABLE 7.1:
Proportion of Undergraduate Time Devoted to Systematic Biology

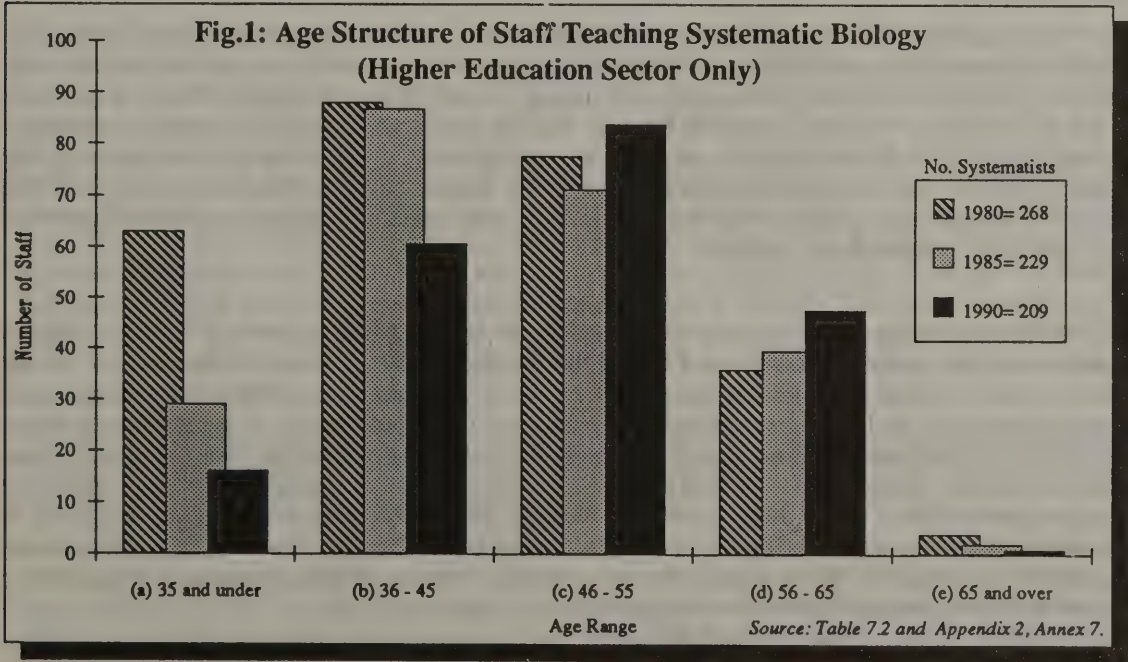
	1980	1985	1990
% of Time	17.1	12.4	8.9

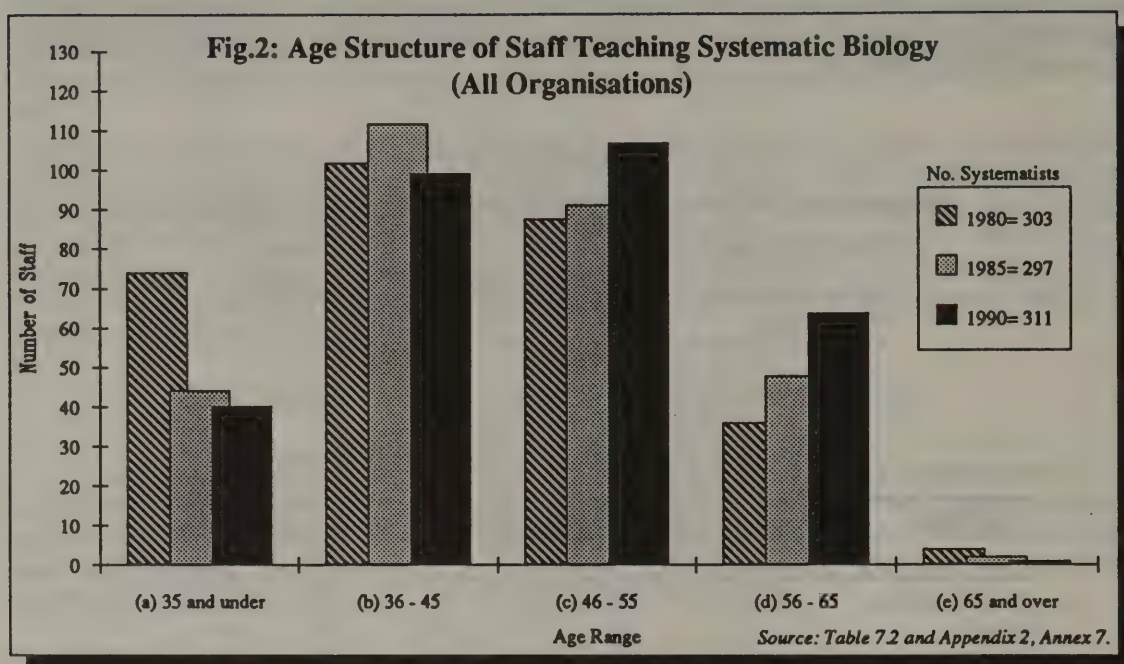
TABLE 7.2:
Age Structure of Staff Teaching Systematic Biology

Age Band	No. Teaching in HEIs			% Total in HEIs		
	1980	1985	1990	1980	1985	1990
35 and under	63	29	16	23	13	8
36-45	88	87	61	33	38	29
46-55	78	71	84	29	31	40
56-65	36	40	48	13	17	23
66 and over	4	2	1	1	1	0
Total in Higher Education	268	229	209	88 ¹	77 ¹	67 ¹
Total in All Organisations	303	297	311			

¹ Total in Higher Education expressed as % of Total in all organisations

7.7 Our survey also showed that while there had been an increase of about 2 per cent in the total number of staff teaching systematic biology in all organisations between 1980 and 1990, from 303 to 310, those in higher education had fallen almost 25 per cent from 268 to 209. This declining population in higher education is also ageing rapidly. Thus in 1980, 24 per cent were aged 35 and under and 44 per cent were aged 46 and over; in 1990 only 8 per cent were aged 35 and under and 63 per cent were 46 and over. Indeed, this is true of the systematic biology teaching community as a whole (Table 7.2). Figures 1 and 2 illustrate the ageing process only too clearly. Age distribution information yielded by the Linnean Society survey confirms the picture for 1990.





7.8 Professor Prance of Kew reported to us a survey of whole plant botanists in 20 universities which showed a decline in staff from 82 in 1976 to 43 in 1991. The number of systematists amongst them had fallen from 39 to 22 (RBG Kew Q 342).

Postgraduates

7.9 The decline in undergraduate activity had not yet been compensated by any increase in taught postgraduate courses for masters degrees. We learned in evidence that only two courses were currently available—in Plant Taxonomy at Reading University and in Applied Insect Taxonomy at the University of Wales College of Cardiff, though five other courses contained systematics components. A new course on plant taxonomy was being planned at Edinburgh University and the Reading course was being revised (Greenwood p.91; Heywood p.99; Claridge *op.cit.*; SOAFD p.85). The course at Reading we were told was heavily patronised by overseas students. There were very few home postgraduate students.

7.10 Postgraduates pursuing pure research degrees at United Kingdom universities declined slightly over the period, falling from 196 in 1980 to 180 in 1990 (Table 7.3). In the view of one witness, most doctoral students in systematics were being supervised at the NHM because adequate supervision could “no longer be supplied in universities” (Patterson p.163). Our own survey shows that, although the number of postgraduate research students supervised at the NHM more than doubled over the period 1980 to 1990 from 13 to 32, NHM still only accounts for 13 per cent of all postgraduate students researching systematic biology. Moreover, despite a small decline from 79 per cent to 66 per cent of the total, the universities still account for the bulk of postgraduates (Appendix 2, Annex 7). RBG Kew wrote that the supervision of postgraduates had placed “a hidden heavy burden on the biodiversity institutes” (RBG Kew P.97).

TABLE 7.3:
Number of Postgraduate Research Students¹

	1980	1985	1990
Higher Education	202	178	192
All Organisations	255	258	290

¹ Due to the possibility of double counting, totals for the Higher Education sector are shown separately.

The effects

7.11 Witnesses were under no illusions as to the likely consequences of the decline of systematic biology teaching at universities. The supply of suitably educated systematists was drying up. As Manchester Museum cogently put it, “We are living on the expertise of pre-1970s graduates and when they are gone we will have no replacements” (Manchester Museum p.137; see also European Garden Flora Project p.75). Shortages were already being felt. The NHM was finding difficulty in recruiting from within the United Kingdom to fill its research posts (NHM p.157) while CABI complained that “Taxonomists in the fields relevant to the CAB International Institutes are not now being produced by the United Kingdom universities so that they have increasingly been forced to train staff in post” (CABI p.45). There appeared to be a downward spiral. RBG Kew wrote tellingly “There is much to suggest that there is an acute shortage of plant taxonomists in the United Kingdom—we have appointed several foreign nationals to posts at Kew recently—United Kingdom applicants have been few in number and not good enough. British universities are just not turning out suitable people. We are also receiving more and more requests for assistance in providing the systematic base for aid projects, etc—and yet we have insufficient manpower to provide this back up. If we had the resources we could go out and hire—but increasingly we find there are few suitable candidates available” (RBG Kew P.97). Another witness maintained that, in spite of there being fewer career opportunities in taxonomy “insufficient young scientists are entering the field. In the long run, this threatens a major manpower crisis” (Lawton p.133).

7.12 Biologists were graduating with no knowledge of systematics and what it could offer them. As Dr Ingram, Regius Keeper of the RBG Edinburgh said, “... we are producing a generation of graduates who not only know no systematics but, indeed, do not know what they do not know so are not in a position even to determine what systematics has to offer them” (Scottish Office Q 304).

What went wrong?

7.13 Our evidence suggest that systematic biology went into decline at the universities because the biologists themselves deserted it. The principal reason was undoubtedly the pressure to include new subject areas in biology courses like cellular and molecular biology, biochemistry, mathematics and computing (Anderson p.5; Patterson p.163; Prance Q 326). The replacement of general courses with the course unit system in the University of London was thought to have hastened the process. As Prof Davies wrote, “Forty or so years ago, most university courses in botany and zoology had a fairly strong systematic framework based on the higher taxonomic categories, within which plant and animal diversity was studied in a comparative fashion. Since then there has been a strong tendency to reduce the importance of such core courses or even to abandon them altogether in favour of courses in comparative physiology, ecology, cell biology, molecular biology, genetics, evolutionary biology and applied biology. The change in attitudes had been accentuated by the widespread introduction of curricula based on a unit-course system. The result has been to divorce the study of plants and animals from its taxonomic context, at least in the minds of the students” (Davies p.66).

7.14 This tendency was further encouraged by increasing pressure on universities to attract external research funding. Systematic biologists do not as a rule attract large research grants—whether from the research councils or elsewhere (see para 5.10 above).

7.15 Broadly speaking the sequence of events was that public funding for universities ceased to rise as quickly as the demands that were placed upon it; expensive molecular biology and biochemistry brought big grants the heavy *pro rata* overheads of which helped to compensate for restrictions on core funding; university staff appointments had been influenced by the need to win such grant support and this meant that new appointments had to be in the big grant-pulling areas.

Similar pressures had been experienced in United States universities, we were told on our visit to Washington.

7.16 Meanwhile systematic biology was ill-equipped to compete. Old fashioned systematic biology was held in low esteem by experimental biologists and had often not been popular with undergraduates (Davies p.66; Bisby p.18; AFRC QQ 212—3). AS RBG Edinburgh lamented, “It is a sad fact that fashion in science results in imbalance in both teaching and research in traditional areas, even though these often underpin new developments” (RBG Edinburgh p.114). There was now some evidence of a revival in undergraduate interest, however (Krebs QQ 212—3).

Suggestions for change

7.17 *Undergraduates and MSc courses:* Most witnesses who ventured an opinion felt that the most feasible remedy lay in developing postgraduate MSc courses, rather than attempting a large scale resuscitation at undergraduate level. A number of witnesses considered it highly desirable that undergraduates in biological sciences were given a good grounding in systematics (Lawton p.133). Prof. Anderson wrote, “A foundation course aimed at principles and methods in the first and second year is desirable. However, I would prefer to introduce the relevance of the subject in other courses (eg ecology, microbiology) and then to encourage the establishment of one or two MSc courses at appropriate universities ... with earmarked studentships from NERC” (Anderson p.5). As the Royal Society put it, “The professional training of people in taxonomy and systematic biology is best undertaken at postgraduate level, building on broader biological skills and interests developed during undergraduate studies” (Royal Society p.113; see also Davies p.66; British Ecological Society p.25). Prof. Lawton suggested that “A national MSc course in taxonomy would be one possible answer, producing a small but steady stream of graduates with an understanding of the problems and needs of the subject, and trained in basic techniques” (Lawton p.133).

7.18 A “critical mass”: Some witnesses also proposed that systematic biology should now be concentrated in fewer university departments with larger numbers of practitioners because “with the widening range of skills, no department can give the necessary depth” (Bisby p.18; see also British Ecological Society p.25).

7.19 Prof. Davies wanted the “Establishment of a few specialised research centres in systematic biology, similar to the Research Council Units or Interdisciplinary Research Centres (cf the MRC Microbial Systematics Unit at the University of Leicester)” (Davies p.67).

7.20 *A role for the institutions:* There were already links between universities and the major institutions like the NHM and the Botanic Gardens. Witnesses thought that these should be developed further at three levels—for undergraduate teaching; for postgraduate supervision; and through joint staff appointments.

7.21 A close relationship between university museums and undergraduate courses existed only at Oxford and Cambridge according to Prof. Krebs (AFRC Q 213). The integration of the Oxford University museum and the Departments was well set out in a letter we received from the Principal Curator which stated that “There are, therefore, links at several levels between the Departments and the Museum: the Curators are members of the Departmental teaching staff; the Curators and Professors sit on the Museum’s governing body; the Professors, Curators and Assistant Curators supervise graduate research on the collections, and use the collections in undergraduate teaching of systematics. Another important link is the use of the collections by other members of the Departments in their teaching and research projects on systematics, palaeontology, evolutionary biology etc” (Simpson p.317). Contact with undergraduate teaching at Manchester Museum was very slight (Manchester Museum Q 1092). Liverpool Museum (not a university museum) had recently been used by the university and staff had been invited to give lectures in systematics.

7.22 Generally speaking, our own survey showed that staff at the institutions had relatively little to do with undergraduate teaching. In 1990, out of 772 systematist man years in all organisations surveyed, 202 were spent in teaching and 167 in supervision of postgraduate research students—26 per cent and 22 per cent respectively. But at the major institutions the relationship was even less; out of 288 systematist man years in the national museums, only 6 per cent and 8 per cent respectively were devoted to teaching and supervision of research students (Appendix 2, Annex 7).

7.23 Many witnesses felt that the institutions had an important role to play in MSc courses and supervision of doctoral candidates. Prof Anderson wrote of the desirability of an MSc course at the Imperial College of Science, Technology and Medicine and the Natural History Museum, for example (Anderson p.5). Prof Davies thought that any expansion of taught MSc courses should be in collaboration with the staff of major taxonomic institutions. For supervision of research

students, a model already existed in the University of London Public Research Institute Scheme for higher degrees for joint supervision of research students by university staff and specialists from the institutions (Davies p.66). The staff of RBG Kew regularly contribute to the teaching of the MSc course at Reading, where they hold adjunct appointments (Prance QQ 331, 345).

7.24 CASE (Collaborative Awards in Science and Engineering) awards from research councils may be shared between the NHM and other systematic institutions on the one hand and the universities on the other. NHM and RBG Kew complained about the level of contribution they had to pay to the universities (NHM p.157; RBG Kew P.95).

7.25 Both institutions and universities seemed ready to forge links through joint appointments. NHM told us of their joint appointment with Imperial College in micro-palaeontology and proposed appointment in molecular systematics (NHM Q 166; May Q 999). CABI told us that the removal of the International Mycological Institute to a site next to Royal Holloway College of London University would foster collaboration. Indeed all CABI institutes collaborated in university teaching to some extent. Prof. Hawksworth told us that his own instinct was for "much stronger links between existing research institutes and universities themselves in collaborative programmes" (CABI Q 535).

7.26 Thus evidence seemed to show that while some links already existed between institutions and universities, especially for postgraduate teaching, both sides recognised that these could be developed further. Such relationships should not, however, be exclusive. As Dr Chalmers said of the connection between NHM and the Imperial College "I do not want it to cut us off from relationships with other universities around the country or around the world" (NHM Q 712). In the United States, where formal teaching and research collaboration between the institutions and the universities was already more advanced following the decline of systematics at U.S. university colleges, we learned how the American Museum of Natural History in New York collaborated with five universities including Yale and Cornell—both some considerable distance away.

COMMITTEE OPINION

Taught courses

7.27 The contraction of systematic biology at British universities is in no small measure the inevitable consequence of the rapid expansion of other branches of biological science since the late 1950s. We think it desirable that new developments in science be reflected in university courses and appointments and that the process is irreversible. But we think that accommodating these new disciplines may have placed systematics as a sustainable discipline in itself in danger of extinction. We accept that there has been a shrinkage in systematics at undergraduate level such that in most universities it appears only as a scantily taught adjunct to another course; taught postgraduate MSc courses exist at only two centres where most of the places are occupied by overseas students; postgraduate research students, while they remain constant in number, are in many cases supervised in the institutions. To cap it all, the age structure of university systematists is such that, in nature, it would give rise for the concern for the continuation of the species. Even allowing for the contraction of the labour market for systematists there is now a shortage of qualified personnel. We think that this is conclusive proof that something has gone wrong and that the situation needs to be stabilised lest systematic biology cease to be a sustainable discipline. And we draw attention to the fact that the peer review system as it has hitherto been operated by the research councils has failed to protect the subject.

7.28 We consider that systematic biology is an essential part of virtually all biological sciences and that it should be provided to undergraduates as an element in those courses. But there will continue to be a demand for more specialist systematists in the institutions. They will also be needed, albeit on a shrunken scale, at the universities—the educators will themselves need to be educated. In line with a number of our witnesses we therefore recommend that specialist teaching in systematic biology be provided through taught MSc courses. To that extent only should systematic biology be concentrated in particular centres.

7.29 MSc courses do not, however, grow on trees. They need to be funded and provided with research council studentships. We therefore further recommend that ABRC assess the need for trained systematists and MSc courses in line with their requirements, and provide enough quota studentships to enable more British postgraduates to take advantage of existing courses.

7.30 We agree with those witnesses who advocated the involvement of the institutions in the setting up and running of such courses. Given the age structure of university systematists and given that, even if our recommendations were to be put into effect, numbers are unlikely to do more than

stabilise, possibly at an even lower level than at present, the staff of the museums and gardens will inevitably be called upon more and more to provide the know-how which the universities will have lost. And the graduates of such courses may well be encouraged to seek employment in the institutions—in itself a desirable by-product of that collaboration. We recommend that MSc courses should therefore be developed with the collaboration of appropriate institutions.

Postgraduate research

7.31 We hope that by stabilising the systematic content of undergraduate courses and by support for taught MSc courses, candidates for higher research degrees will come forward in greater number. To provide for this slight expansion we recommend that some of the new money for systematic biology research which we recommended in chapter 5 will take the form of grants and studentships leading to doctorates.

7.32 We note that institutions are playing an increasingly important role in supervising postgraduate research, while the universities remain the degree awarding body. To the extent that such students carry out work on behalf of the institutions, we suggest that the institutions should encourage rather than resent the practice.

Links with institutions

7.33 We think it highly desirable that stronger links be established between the universities and the institutions. Indeed, our recommendations on taught MSc courses and the role which some institutions already play in supervising research degrees make this inevitable.

7.34 We envisage that such links will evolve naturally. We do not consider that they need be in any way exclusive—whether for teaching of courses, or for supervising research. But links with neighbouring institutions will clearly be easier to sustain. It seems to us surprising that, over the years, closer ties have not been established between the Imperial College and the NHM, for example. We therefore recommend that institutions collaborate fully with universities in the latter's provision for systematics in the future.

CHAPTER 8 MODERN METHODS

8.1 During the nineteenth and early twentieth centuries, systematic methods changed very little and relied on the use of relatively simple structural characters, often subjectively chosen and interpreted in purely qualitative ways.

8.2 But during the last three or four decades a wide range of methodological and technological developments made their impact on systematics, so that already by the fifties and sixties methods unknown to the classical systematists of the last century were influencing the ways in which organisms were classified. These included transmission electron microscopy (TEM) which gives details of the internal structure of individual cells; scanning electron microscopy (SEM) which give information on minute surface details of pollen grains, insects wings etc; and a wide range of biochemical techniques (chromatography, electrophoresis, immunology) relating to the composition and metabolism of living organisms. In addition, the use of conventional light microscopy applied to the study of chromosomes, giving a suite of chromosomal features, revealed new aspects of relationships between species and higher groups. These new techniques brought new labels to systematic research, such as chemotaxonomy and cytotaxonomy, relating to the use of biochemical and chromosomal characters respectively. New approaches have also been developed for assessing the significance of one kind of attribute against another in arriving at a taxonomic arrangement. These have included numerical taxonomy and cladistics, both of which have claimed to offer a less subjective approach to the process of grouping organisms. In the context of the present report, none of these methods can be regarded as “new”, although they have transformed both the approach and the end product of taxonomy within the lifetime of many of its practitioners.

8.3 Within the last decade only, three additional techniques have made their impact and perhaps qualify as “new” tools in biological systematics—molecular biology (in the form of “molecular systematics”), information technology and image analysis. While the first of these has generated an entirely new category of systematic information, the latter two are essentially merely ways of handling data more swiftly or productively.

8.4 Most of our witnesses, when invited to comment on new methods in systematics research focused immediately on the contribution of molecular biology, particularly DNA sequencing, and

the use of modern information technology to set up taxonomic databases of various kinds. We consider each in turn. We also consider briefly whether research in our leading institutions and universities requires better coordination.

DNA

8.5 Molecular biology has brought to systematics the means of getting a direct measure of the degree of similarity between organisms at a very fundamental level. By use of the polymerase chain reaction procedure to amplify a fragment of the DNA from a plant or animal, followed by “sequencing” the base units within it, parts of the genetic makeup of an individual organism can be analysed. This can then be compared with a related group, in terms of the detailed “blueprint” which governs their development and reflects their evolutionary history. Thus characters can be used which are of greater genetic significance than those available to “classical” systematists. These techniques are of value not only in giving exact meaning to relationships at the level of closely related species, and to groups of individuals within a species, but also to very basic problems such as the evolutionary relationship between fungi and higher plants, and between the major groups of animals.

8.6 As we saw in chapter 2, new techniques involve laboratory facilities not previously associated with systematic research. Since work in this field is already well advanced in the USA in many centres (Davies p.65) there is some concern that the United Kingdom is dropping behind in a race which is leading systematic research into a new era. Thus witnesses spoke variously of the United Kingdom being “slow to embrace new methods” (Anderson p.4); and of support for DNA work being “very poor” (Bull p.31). Evidence showed that British systematists were “aware of these developments” and were “embracing them to the extent that resources and expertise allow” (NERC P.29—30). Lack of funding was the problem (Systematics Association p.187; RBG Kew PP.93—94).

8.7 Major institutions like the NHM and RBG Kew had already made some commitment to DNA sequencing and established their own facilities (Patterson p.164; RBG Kew P.94). Most universities had laboratories where such work might be done (Patterson p.164). But because of the cost of such facilities there was some debate as to how far they should be installed in the “biodiversity institutes”. One academic witness regretted the NHM’s establishing a molecular laboratory “... instead of using the expertise in the universities” (Round p.174). Indeed, many of the principal performers of systematic biology research appeared to be under no illusions as to the practicalities of engaging in molecular work and looked to collaboration with universities or the establishment of centres of excellence. Thus RBG Edinburgh had no intention of establishing their own in-house facilities at present but would seek links with universities and other institutes and try to contract the work out (RBG Edinburgh pp.112—3). CABI thought that “As there are established molecular biology groups in universities and government institutions other than museums, such work can often be carried out effectively by collaboration between taxonomists based elsewhere and centres with such skills” (CABI p.43). The National Museum of Wales spoke of the need to use scarce resources in centres of excellence and NERC wrote of focusing molecular methods where they were likely to be of greatest benefit (NMW p.151; NERC P.29—30).

8.8 There was however a problem of access. Existing equipment we were told was used for other experimental work and taxonomists rarely “have more than occasional access to such facilities” (Burnett p.35). Unless there was a way of initiating cooperative research between the higher education establishments and the taxonomic establishments there was “little chance” that the facilities would be used for systematic research (CCBR p.57).

8.9 In any case, it was impressed upon us, molecular systematics supplemented rather than supplanted traditional, collection based, morphological taxonomic skills (RBG Edinburgh p.111; RBG Kew P.94; AFRC P.60). While the range and sophistication of systematics was growing rapidly much systematic biology did not make use and did not need to make use of molecular and other recently developed techniques (Davies p.64).

Information Technology

8.10 Another area in which rapid progress has been made since the 1950s but where application to systematics in the United Kingdom is deemed to have been slow is the use of information technology (IT) in handling biological systematic data. The application of IT has had an impact in three quite separate ways.

8.11 It has the potential to generate a database giving swift access to any particular specimen in a large collection. At the same time it generates labels for new accessions, and produces a complete inventory of all the specimens in a collection. Such computerisation of holdings in a museum or herbarium reduces the time spent in the laborious hand-writing of records, and gives immediate access to any specimen in a collection.

8.12 Through its capacity to handle large amounts of comparative information, IT can subject the similarities and differences between large numbers of specimens to various programmes of data handling. This can then generate (by "cladistic analysis" for example) classifications which to some extent reduce the subjective element of classical taxonomic work.

8.13 Computerised data stores of systematic information can, with suitable software, be "interrogated" so as to lead to the identification of an unknown organism. Such databases can also contain a wide range of additional information about the organisms concerned, such as their ecological setting, their potential use as (for plants) crops, or as a source of timber or as a renewable fuel, and all the other information relating to their value to man. In this way, someone of quite limited training can arrive at the identification of an unknown plant or animal, and acquire the essential relevant information about it. To this extent, IT can greatly shorten the time involved in working through "keys" to find the identity of a specimen which could otherwise only be named by an expert.

8.14 Witnesses attested to the need for development and application of appropriate computerised taxonomic databases (Bisby PP.13—18; Anderson p.4; CABI P.43). United Kingdom activity in this area appeared to be patchy. CABI's institutes are the most advanced of the institutions, having started to instal specimen tracking systems in 1989. CABI considered that there was "no reason why such methods should not be adopted almost immediately for accessions at all major United Kingdom institutions and museums" (CABI p.43). But clearly this was not happening. NHM wrote that "... in the United Kingdom the majority of databases are comparatively small compared to their potential size and the full range of developments is not being exploited ..." (NHM p.156). Indeed, only a small part of NHM's vast collections were as yet included in computerised databases. They had to be selective (NHM QQ 695—706). This has led to unfavourable comparisons being made between NHM and the more advanced CABI (Greuter p.92). Dr Bisby thought that United Kingdom R&D of systematics applications of information technology had been "spectacularly low. Only three small bioinformatics laboratories and two small software partnerships exist in Britain and involvement at the NHM and Kew has been insignificant" (Bisby p.13).

8.15 On the other hand, the Oxford Forestry Institute had developed a micro-based system called BRAHMS (Botanical Research and Herbarium Management System) (Oxford Forestry Institute p.32). Manchester Museum had initiated a database of information on natural history collections themselves, which has since been taken over by the Museum Documentation Association with Museums and Galleries Commission funding (FENSCORE p.77). A few individual systematists were also active in the field. Dr Bisby of Southampton University specialises in species diversity information systems and initiated the International Legume Database (ILDIS) and the Global Plant Species Information Service (GPSIS) (Bisby p.13). The World Conservation Monitoring Centre at Cambridge was coordinating a European plant database (NHM Q 697). We were told that many databases had been established worldwide on microbial strains. In the United Kingdom, DTI had funded the Microbial Culture Information Service (MICIS) which on completion had been transferred to Germany because United Kingdom support was discontinued. Meanwhile the EC had developed the overlapping Microbial Information Network in Europe (Kirsop p.130).

8.16 United Kingdom institutions cooperate in a number of international projects to develop databases. ILDIS received seconded assistance, but little cash, from the United Kingdom, USA, USSR, China and New Zealand. GPSIS and the Species Plantarum are a linked initiative to generate a taxonomic checklist of all the world's plants based on present knowledge and then to develop a system to deliver the data worldwide. United Kingdom centres like Kew and Southampton University and the software industry collaborate in this with European, US and Australian partners (Bisby p.13). The NHM were working with Missouri Botanical Garden in the Flora Mesoamericana project which aimed to identify and name the entire set of vascular plants in Central America (NHM QQ 702—6). International standards for the capture and exchange of such data were currently being developed for botanical groups by the IUBS Taxonomic Databases Working Group (CABI p.43).

8.17 Witnesses considered that British effort in applying IT to systematics was hampered by lack of funding. One witness described in detail how research council funding had not been forthcoming for a proposal derived from the ILDIS project on the grounds that it “did not contain the essential elements of scientific research” required by the SERC’s Plant Sciences and Microbiology Sub-Committee (Bisby p.18). Nor were the international agencies—EC, IUBS, UNEP or FAO—producing adequate funds (ibid p.17). Prof. Blundell of AFRC thought that “if there is more funding to go into the area of biological systematics, perhaps it has to go into the coordination and information technology level” bringing out the full value and making more accessible the collections which we have (AFRC Q 208). It was also claimed that there was little domestic United Kingdom coordination in producing databases (NERC, PP.29—30).

8.18 During our visit to the United States we learned that the US Museum of Natural History was working on a nationwide data recovery programme for systematics collections—the MITRE project. The Academy of Natural Sciences in Philadelphia is also very active in the field (Cain p.48). One of our United Kingdom’s witnesses suggested that such was the United Kingdom lag behind the Americans in work on databases that “it will be an advantage to let the American systems get through their teething troubles before adopting one” (ibid.).

Science Advisory Boards

8.19 In view of recent developments in systematics research, we considered with some interest the evidence we received on the ways in which our major systematics institutions sought the advice of a wider scientific community in planning their research activities.

8.20 Traditionally, institutions like the Royal Botanic Gardens and the NHM have received periodic independent scientific audits of their work by the Visiting Group method at the request of the Trustees (RBG Edinburgh PP.82—3; RBG Kew Q 337). At Edinburgh, the last one took place in 1983 and another is currently proposed. Generally speaking, the major institutions have not established continuing bodies to provide advice, beyond that which might be provided by their trustees.

8.21 There have, however, been some developments on this front. Thus the Regius Keeper of the RBG Edinburgh had recently established a small Scientific Advisory Group (RBG Edinburgh P.82). Kew has a Scientific Policy Committee which is a sub-committee of the Trustees. The National Museum of Wales, as of August 1991, had set up advisory committees for each department, chaired by the respective Keepers. Thus all projects are subject to peer review by some “six or seven people who can cover the whole field of the work of the department, including research, collections, exhibitions, and indeed who can have some overview of the external work that we do” (NMW QQ 1128—31). The National Museum of Scotland, by contrast, continued to rely on their Trustees, who happened to include a biologist (NMS Q 1132).

8.22 During our visit to the United States we learned of steps being taken to strengthen internal scientific advice available to the research programmes of some of the major institutions. Thus the US Museum of Natural History and the New York Botanic Garden had recently set up advisory boards while the American Museum of Natural History had recently appointed more scientists to its governing body.

COMMITTEE OPINION

8.23 We consider it essential that systematic biology be in a position to take advantage of all that modern science can provide including recent developments in molecular biology and in information technology. And we consider that new developments should supplement rather than supplant traditional taxonomic expertise.

8.24 We agree with those witnesses who were cautious as to the need to establish expensive molecular biology facilities in all the research institutions. We hope that more molecular systematics might be done at the universities where molecular biology facilities by and large already exist. This access would be facilitated if closer contacts were developed between the institutions and the universities as set out in chapter 7.

8.25 We agree that considerable benefit would accrue from selective application of IT to systematics and that more could be done within the United Kingdom. But we are disturbed by the apparent anarchy currently prevailing both within the United Kingdom and at international level in the field of IT for systematics. While it may well be impractical to devise software that will be universally applicable, it should be possible to establish standards for the exchange of data between

different systems and the work of the International Union of Biological Sciences (IUBS) Commission on Plant Taxonomic Databases is to be applauded.

8.26 So far as concerns the systems themselves, United Kingdom research should try to be compatible with work currently well ahead in the United States.

8.27 We therefore recommend that research into IT for systematics should be eligible for assistance from the extra provision from ABRC, but having regard to and favouring collaboration with work under way at the US institutions.

Advisory Groups

8.28 We think that the practice of appointing standing advisory groups or committees of experts at the "biodiversity institutes" is very much to be encouraged. Some of the boards which govern these institutes do not always adequately appreciate the significance and importance of the changes that have taken place in systematics and more expert opinion should be available to advise them on the scientific content of their programmes. The advisory groups would also be in a position to monitor and report on standards of curation and the state of the collections. This does not imply that *ad hoc* Visiting Groups should not also be appointed by the governing bodies from time to time.

8.29 Accordingly, we recommend that, to the extent that they may not already have done so, the national museums and gardens appoint standing advisory groups of experts to advise on scientific programmes and standards of curation.

CHAPTER 9 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

9.1 Systematic biology research is not only of central importance to evolutionary theory but also provides an essential framework to most other branches of applied biological science. Its benefits to mankind both in economic and human terms can be also large. (3.24)

9.2 The quality of the systematics collections and the expertise of our systematists also places the United Kingdom in a unique position to contribute a firm scientific base to the current world drive to conserve biological diversity. (3.25)

9.3 Systematics research and curation of the collections on which it depends should therefore be maintained in good order. (3.26)

9.4 Ultimately, and properly in our view, public funding of one sort or another bears the brunt of expenditure on systematic biology research. But public expenditure policy has meant that core funding of the major institutions has not been maintained in real terms and this has affected both the quality of curation and the amount of research performed. The criteria of originality applied by the research councils has meant that applications for support for many kinds of traditional systematic research have gone unfunded. And universities' own research facilities, on which systematists have relied, are themselves under pressure.

9.5 As an academic subject in the institutes of higher education it has been widely displaced by newer areas of biological science and the increasing average age of systematists in the faculties is such as to render them almost an endangered species in themselves.

9.6 In our view these circumstances have all conspired to place systematic biology—the research itself, the curation of the collections, and its position at the universities—at a risk which the nation can ill afford and which reflects poorly upon the traditional, peer review, mechanisms for the funding of science today.

9.7 Our principal recommendations are that in future core funding for research at and curation of the collections in the major systematics institutions be maintained in real terms; that ABRC establish a special fund for five years of £1m a year for systematic biology research; that OAL set up a rolling programme of up to £0.5m a year to assist systematics collections outside the grant-aided institutions; that a new forum of systematics institutions be established to rationalise holdings and expertise; and that ABRC assess the need for trained systematists and fund MSc courses in line with those requirements.

9.8 Taken together with our other recommendations we hope that these modest measures will give systematic biology research a much needed stimulus, after which we expect the subject to take its place with other branches of science.

9.9 Our more detailed conclusions and recommendations are:

Decline in Research Funding

9.10 Funding for and manpower engaged in systematic biology research have fallen in real terms in recent years because core funding of the major institutions by Government has not been maintained in real terms; support from the research councils through “responsive mode” funding or research grants has fallen; and universities own free funds for research are being squeezed by other factors. (5.47-48; 5.53)

9.11 There is for the foreseeable future no viable alternative to Government core funding of systematic biology research, which should be maintained in real terms. (5.47—48)

9.12 The Office of Arts and Libraries should continue to fund the Natural History Museum but should establish an expert scientific panel to advise it on the Museum’s requirements. Such a panel might also be consulted on the annual spending bids of any other natural history grant-in-aided institution, whatever the parent Government Department. (5.49)

9.13 The Cabinet Office and research councils should press for the inclusion of more systematic research in the next EC Framework, subject only to a relaxation of Treasury practice relating to attribution and additionality so as to guarantee some element of additionality. (5.50)

9.14 The Government should monitor closely the way in which the World Bank’s Global Environment Facility funds are disbursed. (5.52)

9.15 Systematic biology research has not fared well under the research councils. ABRC, using its powers to protect subjects which fall between the research councils’ responsibilities, should set up a fund of £1m per annum for five years exclusively for systematic biology research beyond the routine research activity associated with monitoring the collections. (5.54)

9.16 All grant-in-aided institutions should, like the Natural History Museum, be eligible for research council grants. (5.55)

9.17 Aid projects funded by the Overseas Development Administration and dependent upon systematics should as a general rule include funding for a United Kingdom based research project at one of the major institutions with appropriate overheads. (5.56)

Curation of the Collections

9.18 United Kingdom institutions hold systematics collections which are unique and of inestimable value to world science. These collections are indispensable to systematic biology research and should be properly maintained so that they remain accessible. (6.40)

9.19 Our own survey showed that expenditure on curation had risen overall in real terms between 1980 and 1990 and we suspect that curation has been preserved at the expense of research. Notwithstanding this, we think that all collections have encountered financial difficulties, especially university and local authority holdings. This is now beginning to affect the quality of curation and their accessibility. (6.41)

9.20 Core funding from Government for grant-in-aided national institutions should be maintained in real terms to ensure the long term well being of the collections. This shall include care and maintenance of the collections and such research as is consistent with their preservation as a scientific resource (see also para 9.11 above). (6.42)

9.21 OAL should establish a Biological Collections Fund of up to £0.5m a year to be administered on a rolling basis to assist any systematics collections with research potential outside a grant-in-aided institution. (6.45)

9.22 There is as yet no case for repatriating any of the collections. (6.48)

9.23 Ideally, collections should be the responsibility of a staff member who has an active research interest in the field. At second best, honorary curators from other institutions may be contracted to take on curatorial work. No important collections should be left without regular, though not necessarily continual, attention from a research or scientific officer who is contracted so to do. (6.50; 6.51)

9.24 A new forum should be established by the major systematics institutions to generate a national curatorial policy through discussions on rationalisation of holdings, staff appointments and areas of specialisation. A committee of award drawn from this forum should advise the OAL on applications to the proposed Biological Collections Fund (6.45; 6.55)

Universities

9.25 Systematic biology has contracted at British universities to such an extent that it may be in danger of extinction as a sustainable discipline. (7.27)

9.26 Systematic biology is a necessary adjunct to other biological sciences and should be taught to undergraduates as a part of those courses. (7.28)

9.27 ABRC should assess the need for taught MSc courses and fund studentships according to those requirements. (7.29)

9.28 Candidates for higher research degrees should be assisted by grants and studentships from the new ABRC money for systematic biology research (see 9.15 above). (7.31)

9.29 Closer links should be established between the institutions and the universities to formulate taught MSc courses, to supervise doctoral candidates, and to facilitate access to molecular facilities. (7.33—34; 8.24)

Modern Methods

9.30 Systematic biology research should be enabled to take advantage of all that modern science can provide including recent developments in molecular biology and in information technology. These developments should supplement rather than supplant traditional taxonomic expertise. (8.23)

9.31 Systematists should be allowed access to molecular biology facilities at the universities. (8.24)

9.32 Research into IT for systematics should be eligible for assistance from the extra provision from ABRC for systematic biology research, having regard to, and favouring collaboration with, work under way in the United States. (8.27)

Advisory Groups

9.33 National museums and gardens should, to the extent that they have not already done so, appoint standing groups of experts to advise on scientific programmes and standards of curation. (8.29)

APPENDIX 1

The members of the Sub-Committee who conducted the inquiry were:

L. Adrian
L. Butterworth
E. Cranbrook
L. Dainton (Chairman)
L. Flowers
B. Nicol
L. Porter of Luddenham
E. Selborne
L. Taylor of Blackburn
L. Walton of Detchant
L. Whaddon

The Sub-Committee appointed as their Specialist Advisers:-

Professor W G Chaloner FRS
Professor M F Claridge

APPENDIX 2

Results of the Committee's Questionnaire on the State of Systematic Biology in the United Kingdom

INTRODUCTION

During the course of its enquiry the Committee received a considerable volume of evidence attesting to:

- the decline of Systematic Biology research;
- the decline of teaching of Systematic Biology in the universities; and
- the increase in the average age of the practitioners.

However much of the evidence was anecdotal and the Committee lacked hard facts on which to base possible recommendations. In an attempt to correct this situation the Committee decided to carry out a survey of "The State of Systematic Biology in the United Kingdom". After close consultation with a number of organisations—including NHM, RBG(Kew), University of Oxford, CAB International, Bolton Museum, DoE, NERC and ABRC—a questionnaire was formulated which addressed these, and other related, issues (Annex 2).

The questionnaire was divided into four sections dealing with:

- (i) Expenditure on Systematic Biology (including research, curation and the provision of information services but *excluding* teaching);
- (ii) Sources of Funds for Systematic Biology Research;
- (iii) Manpower engaged in Systematic Biology;
- (iv) Teaching of Systematic Biology.

The questionnaire was circulated, with a covering letter from the Chairman (Annex 1), to about 150 organisations (Annex 3).

Approximately 85 per cent of organisations responded as requested, although about 10 per cent of these said that the questionnaire was not applicable to them as they were not engaged in systematic biology to any significant extent (see Annex 3). Furthermore a number of responding organisations, 21 and 14 respectively, were unable to provide detailed expenditure data for 1980 and/or 1985. However the majority of these organisations did provide information about the general trend in their expenditure, ie. whether it had remained constant, or by what percentage it had increased or decreased in real terms over the period. As a result it was possible, using these general trends, to obtain a reliable estimate of expenditure for the earlier years, and adjust manpower resources accordingly. Only two organisations, RBG(Kew) and CAB International, were unable to provide expenditure data or information about the general trend in their expenditure (both for 1980) and in this case we have assumed that expenditure in 1980 was the same in real terms as in 1985.

Some organisations, in particular the museums and gardens, expressed concern at having to split their expenditure between research and curation. Many considered the two inseparable but made rough estimates for the purpose of returning the questionnaire. RBG(Kew), however, was unable to separate the two and so in analysing their return we have assumed a 50:50 split of expenditure between research and curation. It is worth noting that the NHM return excluded overhead costs associated with collection maintenance.

Despite the above reservations we feel that the questionnaire was worth attempting because the repeated assertion by witnesses that systematic biology in the United Kingdom was declining required corroboration.

Results

In analysing the results of the questionnaire performer organisations were grouped, according to the nature of their activities, into the following categories:

- Museums/National; Regional/Local Authority; University.
- Gardens/National; Regional/Local Authority; University.
- Higher Education/University Departments; Polytechnics.
- Research Council Institutes.
- Government Departments/Laboratories.
- Other Organisations.

Using this categorisation and its sub-divisions a complete set of results for 1980, 1985 and 1990 are listed in Annexes 4–6, respectively. In each case:

- (i) Table A shows expenditure in current (cash of the year) prices;
- (ii) Table B shows expenditure in constant 1990 prices;
- (iii) Tables C & D show the data in terms of the relevant percentages.

The results in Tables 4B–6B are brought together in Annex 7, which highlights the trends that have occurred in expenditure and manpower resources over the period 1980 to 1990.

In the following summary, the results are presented in the same order as which the questions appeared in the questionnaire and for the sake of clarity results are presented using only the major categories of performer organisations, and not their sub-divisions.

Expenditure On Systematic Biology (Excluding Teaching)

Q1. Total expenditure on Systematic Biology in 1980, 1985 and 1990 is shown in Table 1.

TABLE 1

Total Expenditure on Systematic Biology

Expenditure (£million)	1980	1985	1990
Current prices	16.3	21.7	30.6
Constant 1990 prices	29.9	28.6	30.6

Inference:

This reveals that total expenditure on systematic biology, although increasing in current (cash of the year) prices, remained fairly constant in real terms over the period in question.

Table 2 shows the distribution of total expenditure between the different categories of performer organisations.

TABLE 2:
Expenditure By Category of Performer

Category of Performer	£m (1990 prices)			% Total Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	10.8	10.6	10.5	36	37	34
Gardens	4.2	4.0	5.2	14	14	17
Higher Education	4.8	4.3	4.3	16	15	14
Research Council Inst.	4.8	4.3	4.0	16	15	13
Government Labs/Depts.	2.7	2.7	2.9	9	9	10
Other	2.7	2.9	3.7	9	10	12
Total Expenditure	29.9	28.6	30.6			

Inference:

This reveals that Museums are the major players in the field of Systematic Biology, followed by Research Council Institutes, Gardens and Higher Education. [It is important to note that National Museums, National Gardens, and Universities each account for approximately 97 per cent of the expenditure of their respective categories, as the more detailed breakdown in Annexes 4–6 show.]

Q2. Table 3 shows the proportion of total expenditure devoted to research, curation, the provision of information services and other activities.

TABLE 3:
Total Expenditure By Activity

Activity	£m (1990 prices)			% Total Expenditure		
	1980	1985	1990	1980	1985	1990
Research	17.5	16.3	16.5	59	57	54
Curation	6.5	6.5	8.0	22	23	26
Information Services	3.5	3.5	3.8	12	12	12
Other	2.3	2.3	2.4	8	8	8
Total Expenditure	29.9	28.6	30.6			

Inference:

This reveals that the slight decline in resources allocated to research has been mirrored by an increase in the resources allocated to curation.

Tables 4–7 show the distribution of expenditure on each of the activities listed in Table 3 between the different categories of performer organisations.

TABLE 4:
Research Expenditure by Category of Performer

Category of Performer	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	5.9	5.6	4.4	34	34	27
Gardens	1.9	1.8	2.4	11	11	15
Higher Education	3.7	3.1	3.2	21	19	19
Research Council Inst.	4.2	3.7	3.6	24	23	22
Government Labs/Depts.	1.2	1.2	1.6	7	7	9
Other	0.7	0.9	1.3	4	6	8
Total Expenditure	17.5	16.3	16.5			

TABLE 5:
Expenditure on Curation by Category of Performer

Category of Performer	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	2.7	2.7	3.5	42	42	42
Gardens	1.4	1.4	2.0	22	21	25
Higher Education	0.7	0.7	0.7	11	11	8
Research Council Inst.	0.3	0.2	0.2	5	4	3
Government Labs/Depts.	0.8	0.8	0.7	12	12	9
Other	0.6	0.6	1.0	9	10	12
Total Expenditure	6.5	6.5	8.0			

TABLE 6:
Expenditure on Provision of Information Services by Category of Performer

Category of Performer	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	1.6	1.7	1.9	46	48	51
Gardens	0.6	0.6	0.6	18	17	15
Higher Education	0.1	0.1	0.1	3	4	3
Research Council Inst.	0.4	0.3	0.2	10	8	5
Government Labs/Depts.	0.5	0.5	0.6	14	15	15
Other	0.3	0.3	0.4	9	9	11
Total Expenditure	3.5	3.5	3.7			

TABLE 7:
Expenditure on Other Activities by Category of Performer

Category of Performer	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Museums	0.6	0.6	0.7	24	24	29
Gardens	0.2	0.2	0.2	8	9	7
Higher Education	0.3	0.3	0.3	12	13	14
Research Council Inst	0.0	0.0	0.0	0	0	0
Government Labs/Depts	0.2	0.3	0.1	9	11	6
Other	1.1	1.0	1.0	47	44	44
Total Expenditure	2.3	2.3	2.4			

Inference:

These table show that:

- (i) there has been a real shift away from research at museums both in absolute terms and relative to their other activities;
- (ii) research expenditure in research council institutes and higher education institutions declined slightly in real terms;
- (iii) research expenditure by gardens, government departments and other organisations has either remained constant or increased slightly in real terms.
- (iv) museum expenditure on curation has risen in absolute terms but fallen slightly relative to other activities. Interestingly, curation has not collapsed in Higher Education. (Presumably because some collections have simply disappeared and cannot be measured by our survey.)

Q8. Table 8 shows the proportion of total expenditure on Systematic Biology research devoted to salaries, equipment, general overheads and other activities.

TABLE 8:
Breakdown of Research by Category of Expenditure

Category of Expenditure	£m (1990 prices)			% Expenditure		
	1980	1985	1990	1980	1985	1990
Salaries	13.1	12.4	12.1	75	76	73
Equipment	1.3	1.2	1.5	8	8	9
General Overheads	2.4	2.2	2.5	13	13	15
Other Activities	0.7	0.5	0.5	4	3	3
Total Expenditure	17.5	16.3	16.5			

Inference:

This shows that salaries are by far the biggest component of research expenditure and that Systematic Biology is cheap in material support.

Q4. Table 9 shows the source of funds for Systematic Biology Research.

TABLE 9:
Source of Funds for Systematic Biology Research

Source of Funds	£m (1990 prices)			% Total Funds		
	1980	1985	1990	1980	1985	1990
Core Funding	11.5	11.2	10.4	65	69	63
Research Councils	3.3	2.3	2.0	19	14	12
Government Depts	1.2	1.7	1.8	7	10	11
Commercial Organisations	0.4	0.2	0.9	2	1	5
Self-generated income	0.7	0.4	0.7	4	3	4
Other	0.5	0.5	0.7	3	3	4
Total Expenditure	17.5	16.3	16.5			

Inference:

This confirms that Core Funding and Research Council support has fallen sharply in real terms while Government Department spending has increased. It is surprising that self-generated income has remained constant and not risen over the period.

Manpower Engaged in Systematic Biology

Q5. Table 10 shows total manpower, as expressed in man years, engaged in systematic biology, and the distribution of this manpower between the different categories of performer organisations.

TABLE 10:
Manpower Engaged in Systematic Biology

Category of Performer	Manpower (MnYrs)			% Total Manpower		
	1980	1985	1990	1980	1985	1990
Museums	406	400	372	36	36	34
Gardens	180	176	195	16	16	18
Higher Education	186	171	168	17	16	15
Research Council Inst.	132	127	127	12	12	12
Government Labs/Depts.	45	44	49	4	4	4
Other	175	183	185	16	17	17
Total Manpower (MnYrs)	1125	1101	1096			

Inference:

This reveals that manpower engaged in Systematic Biology has remained fairly constant throughout the period of concern. The decline in manpower in the Museums and Higher Education being set against slight increases elsewhere. Not surprisingly the distribution of manpower between the different categories of performer organisations closely matches expenditure (Table 2).

Q6. Table 11 shows the proportion of total manpower engaged in research, curation, the provision of information services and other activities.

TABLE 11:

Manpower Engaged in Systematic Biology by Category of Activity Performed

Activity	Manpower (MnYrs)			% Total Manpower		
	1980	1985	1990	1980	1985	1990
Research	552	547	514	49	50	47
Curation	319	306	324	28	28	30
Information Services	132	124	131	12	11	12
Other	123	125	127	11	11	12
Total Manpower (MnYrs)	1125	1101	1096			

Inference:

This shows that the seven per cent decline in research manpower has not been offset by manpower increases elsewhere. Once again the distribution of manpower closely matches expenditure on the different activities (Table 3).

Q7. Table 12 shows the employment status of total manpower engaged in Systematic Biology research, and research manpower within the different categories of performer organisation.

TABLE 12:

Employment Status of Research Manpower

Type of Employment:	1980		1985		1990	
	%P ¹	%C ²	%P ¹	%C ²	%P ¹	%C ²
Museums	99	1	95	5	66	34
Gardens	98	2	98	2	86	14
Higher Education	75	25	63	37	57	43
Research Council Inst.	93	7	87	13	64	36
Government Labs/Depts.	100	0	90	10	76	24
Other	90	10	82	18	87	13
Average (All Organisations)	91	9	85	15	70	30
Total Manpower (MnYrs)	552		547		514	

1. % Permanently employed. 2. % Employed on fixed term contracts.

Inference:

Although total manpower engaged in Systematic Biology has remained fairly constant over the period (Table 11) Table 12 reveals that there has been a marked increase in all organisations of the percentage of researchers employed on fixed term contracts. The average proportion of researchers on fixed term contracts increasing from 9 per cent in 1980 to 30 per cent in 1990.

Teaching of Systematic Biology

Q8. Table 13 shows the amount of manpower, as expressed in man years, who were: (i) considered to be systematists, (ii) involved in teaching, and (iii) involved in supervising research students.

TABLE 13:

Manpower Engaged in Teaching of Systematic Biology

	Manpower (MnYrs)			% Total ^{1,2}		
	1980	1985	1990	1980	1985	1990
No. Systematists ¹	823	798	772	73	72	70
No. Teaching ²	215	211	202	26	26	26
No. Supervising Research ²	169	161	167	20	20	22
Total Manpower (MnYrs)	1125	1101	1096			

¹ No. of Systematists expressed as a % of Total Manpower.

² No. Involved in Teaching and Supervision of Research Students expressed as % of No. Systematists.

Inference:

This reveals that just over 70 per cent of the total manpower engaged in Systematic Biology are considered to be systematists. However, only about 20–25 per cent of practising systematists are actively engaged in teaching and/or the supervision of research students.

Table 13 also shows that total manpower engaged in Systematic Biology, and the proportion of systematists amongst this manpower declined by about 3 per cent and 6 per cent, respectively over the period. In contrast the number of systematists involved in teaching and/or the supervision of research students remained constant.

Table 14 shows the distribution of systematists between the different categories of performer organisations.

TABLE 14:

Distribution of Systematists by Category of Performer

Performer	No. Systematists			No. Teaching			No. Supervising		
	1980	1985	1990	1980	1985	1990	1980	1985	1990
Museums	313	310	289	3	4	18	12	17	23
Gardens	93	93	108	18	19	23	27	27	33
Higher Education	245	220	199	172	149	123	110	91	79
Research Council Inst.	86	87	85	3	3	3	17	23	23
Government Labs/Depts	35	35	40	5	5	5	3	3	7
Other	52	54	51	14	31	32	0	0	2
Total	823	798	772	215	211	202	169	161	167

Inference:

This reveals that number of systematists in the Museum and Higher Education sectors, declined by about 8 per cent and 18 per cent, respectively, over the period 1980 to 1990. In the Higher Education sector this decline has been accompanied by a comparable fall in the number of systematists involved in teaching and research. In contrast, the decline in the Museum sector has been accompanied by an increase in the number of systematists involved in teaching and research. However, although the Museum sector employs some 40 per cent of systematists, less than 10 per cent of these are involved in teaching and/or the supervision of research students. In contrast, over 50 per cent of the systematists employed in the Higher Education sector (which employs 25 per cent of all systematists) are engaged in teaching and/or the supervision of research students.

Q9. Table 15 shows that the proportion of undergraduate time devoted to Systematic Biology.

TABLE 15:
Proportion of Undergraduate Time Devoted to Systematic Biology

	1980	1985	1990
% of Time	17.1	12.4	8.9

Inference:

Undergraduate time devoted to Systematic Biology declined by approximately 50 per cent over the period 1980 to 1990.

Q10. Table 16 shows that the number of postgraduate research students studying Systematic Biology.

TABLE 16:
Number of Postgraduate Research Students¹

	1980	1985	1990
Higher Education	202	178	192
All Organisations	255	258	290

¹ Due to the possibility of double counting, totals for the Higher Education sector are shown separately.

Inference:

The number of postgraduate research students studying Systematic Biology, as reported by the Higher Education sector, has declined slightly over the period of interest. In contrast, if the returns from all organisations are considered there has been a marked increase in the numbers of postgraduate students. (The extent to which this difference is attributable to double counting is not clear.)

Q11. Table 17 shows the age structure of staff in higher education involved in the teaching of systematic biology.

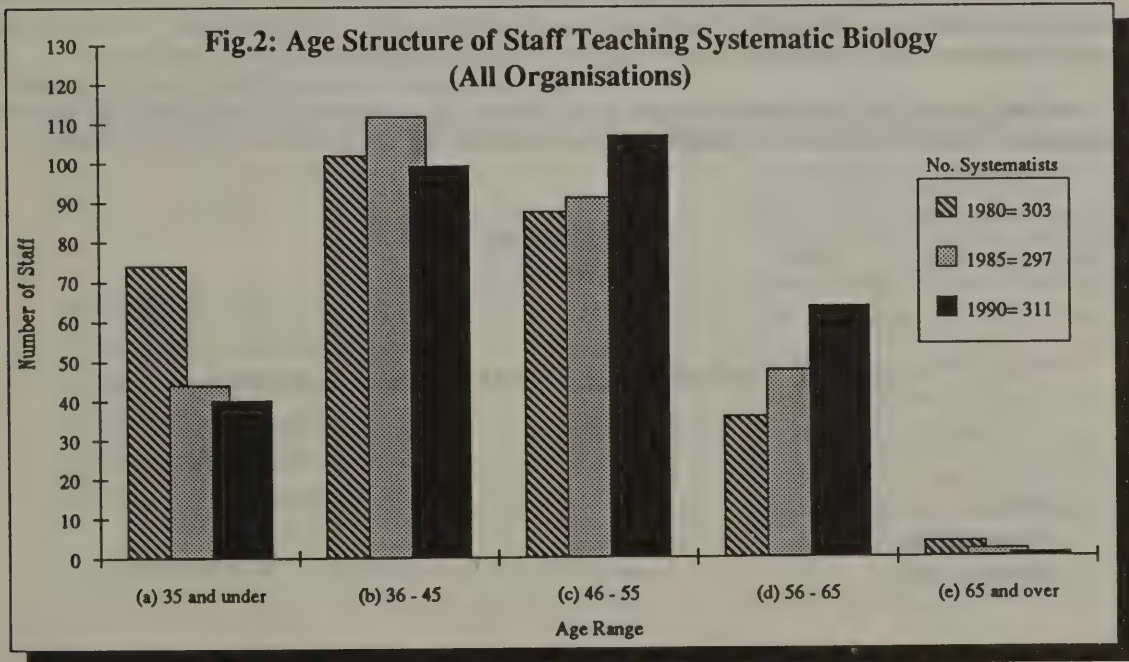
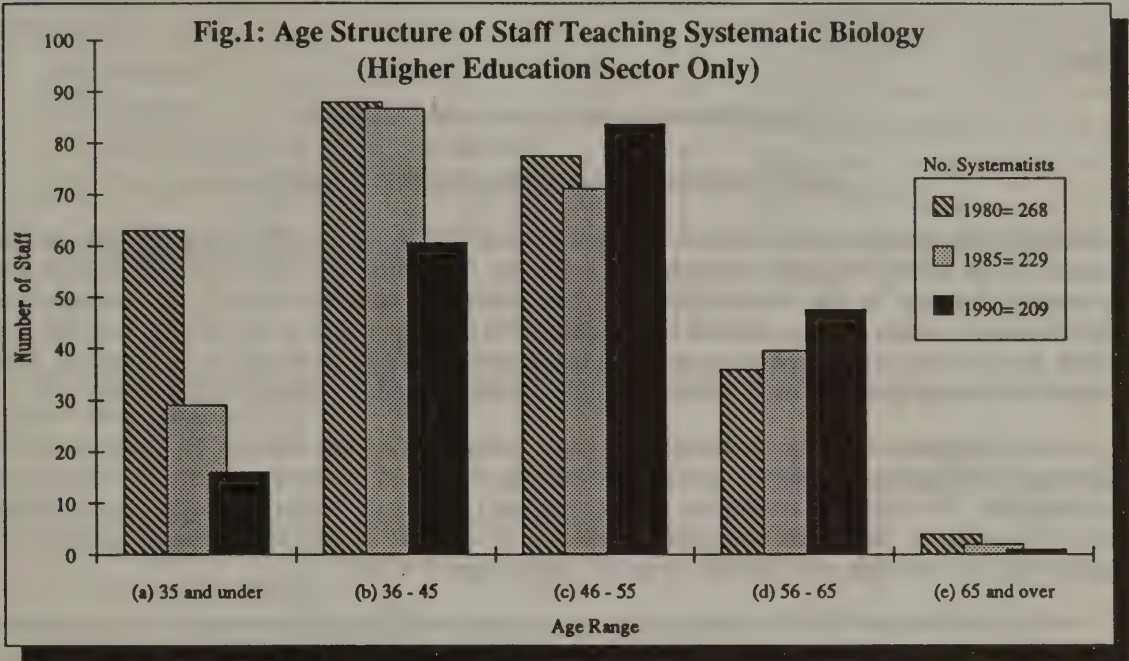
TABLE 17:
Age Structure of Staff Teaching Systematic Biology

Age Band	No. Teaching in HEIs			% Total in HEIs ¹		
	1980	1985	1990	1980	1985	1990
35 and under	63	29	16	23	13	8
36-45	88	87	61	33	38	29
46-55	78	71	84	29	31	40
56-65	36	40	48	13	17	23
66 and over	4	2	1	1	1	0
Total in Higher Education ¹	268	229	209	88	77	67
Total in All Organisations	303	297	311			

¹ Total in Higher Education expressed as % of Total in all organisations

Inference:

Although there has been a slight increase in the total number of staff teaching systematic biology, Table 17 reveals that there has been a significant decline in the proportion of teaching staff in the Higher Education sector. This declining population is also aging rapidly (Figure 1), a feature which is equally true of the Systematic Biology teaching community as a whole (Figure 2).



ANNEX 1

071 219 6075

23 July 1991

Dear

*Select Committee on Science and Technology**Sub-Committee II—Systematic Biology Research*

In the course of our inquiry, we have received a considerable volume of evidence attesting to the decline of systematic biology research in the United Kingdom; the decline of the teaching of systematic biology in the universities; and the increasing average age of the practitioners. Unfortunately, much of this evidence is anecdotal. We have very little in the way of hard facts on which we can base some recommendations. In an attempt to correct this, the Committee have decided to issue a questionnaire, a copy of which I attach together with a list of recipients.

For the purpose of the questionnaire we have defined systematic biology as the description, naming and classification of all organisms, living and dead, and the investigation of evolutionary relationships. We consider systematic biology research to include research in systematic biology carried out for its own sake; research carried out in support of all other areas of science and technology; or research with specific practical application in view.

I realise that the questionnaire may not be easy to complete. Clearly, our request for information relating to 1980 and 1985 cannot be met without some element of research on your part. We know, for example, that many university departments have been reorganised. Nevertheless, we hope that you will make every effort to complete the questionnaire to the best of your ability in consultation with the relevant department(s). If necessary please provide your "best estimates" for the earlier years. Unless we receive answers of good quality, recommendations will lack credibility.

Needless to say, we guarantee you and your institution anonymity. Your returns will not be published. I hope that it will be possible for you to return the questionnaire by 14 October.

DAINTON
ANNEX 2

*SYSTEMATIC BIOLOGY IN THE UNITED KINGDOM**Name:**Organisation:**Telephone No:**Expenditure on Systematic Biology (Excluding Teaching)*

Q1. What was your total expenditure on systematic biology (including research, curation and the provision of information services) in 1980, 1985 and 1990?

Total Expenditure

£'000, historic prices (ie. cash of the year in question)		
1980	1985	1990

If you are unable to provide detailed information for the earlier years please indicate the general trend in the level of your expenditure, ie. whether it has increased, decreased or remained constant, in real terms.

Q2. What proportions (%) of this total were devoted to:

	1980 (%)	1985 (%)	1990 (%)
(a) Research.....			
(b) Curation			
(c) The provision of information services*			
(d) Other activities (please specify in broad terms)			
.....			

*(If separable from research and curation).

Q3. What proportions (%) of your total expenditure on systematic biology research in 2(a) above were spent on:

	1980 (%)	1985 (%)	1990 (%)
(a) Salaries.....			
(b) Equipment			
(c) General overheads.....			
(d) Other activities (please specify in broad terms)			
.....			

Source of Funds for Systematic Biology Research

Q4. What are the main sources of funding for your research in systematic biology?

	£'000, historic prices (ie. cash of the year in question)		
	1980	1985	1990
(a) Core Funding*			
(b) Research Councils.....			
(c) Government Departments.....			
(d) Commercial Organisations.....			
(e) Self-generated income			
(f) Other (please specify).....			
.....			

*(eg. for universities UFC + fee income; for museums core grant).

Manpower Engaged in Systematic Biology (Excluding Teaching)

Q5. What was your total manpower engaged in systematic biology (including research, curation and the provision of information services) in 1980, 1985 and 1990? Please *include* research assistants, postdoctoral workers, etc., but *exclude* research students.

	Number (man years)		
	1980	1985	1990
Total manpower employed			

If staff were involved in performing other duties please estimate the proportion of their time devoted to each activity and express the time spent on systematic biology in terms of man years or fraction thereof.

Q6. What proportions (%) of this manpower were devoted to:

	1980 (%)	1985 (%)	1990 (%)
(a) Research.....			
(b) Curation			
(c) The provision of information services*			
(d) Other activities (please specify in broad terms)			
.....			

*(If separable from research and curation).

Q7. What proportions (%) of the research manpower in 6(a) above were:

	1980 (%)	1985 (%)	1990 (%)
(a) Permanently employed			
(b) Employed on fixed term contracts			

Teaching of Systematic Biology

Q8. How many of your staff (including research assistants and postdoctoral workers, but excluding research students) were systematists and how many were actively engaged in teaching courses or supervising higher degrees in systematic biology?

	Number (man years)		
	1980	1985	1990
(a) No. of Systematists			
(b) No. Involved in Teaching			
(c) No. Involved in Supervising Research Students			

If staff were involved in performing several different activities please estimate the proportion of their time devoted to each activity and express as man years or fraction thereof.

Q9. What proportion (%) of the time of your undergraduate students reading for degrees in Biological Sciences was spent in courses (or parts of courses) which deal wholly or largely with Systematic Biology?

	1980 (%)	1985 (%)	1990 (%)
Proportion of time devoted to systematics			

Q10. How many postgraduate research students were studying systematic biology in your organisation in 1980, 1985 and 1990?

	1980	1985	1990
Number of postgraduate research students			

Q11. What was the age distribution of your staff teaching systematic biology in 1980, 1985 and 1990?

	Number of Teaching Staff		
	1980	1985	1990
(a) 35 and under			
(b) 36-45			
(c) 46-55			
(d) 56-65			
(e) 65 and over			

ANNEX 3

List Of Recipients Of Questionnaire

Those organisations marked* failed to reply to the Committee's questionnaire. Those marked + responded, but said that the questionnaire was not applicable to them.

National Museums

1. The Ulster Museum, Belfast
2. National Museums of Scotland, Edinburgh
3. National Museum of Wales, Cardiff
4. National Museum and Galleries on Merseyside, Liverpool
5. The Natural History Museum, London

Local Authority/Regional Museums

6. City Museum and Art Gallery, Birmingham*
7. Bolton Museum and Art Gallery
8. Booth Museum of Natural History/Brighton Art Gallery and Museum
9. City of Bristol Museum and Art Gallery
10. Royal Albert Memorial Museum, Exeter*
11. Glasgow Museums and Art Galleries
12. Horniman Museum, Forest Hill, London*
13. Nottingham Natural History Museum, Wollaton Hall*
14. Castle Museum, Norwich
15. Clifton Park Museum, Rotherham
16. Sheffield City Museum
17. The Botanic Gardens Museum, Southport +
18. Tyne and Wear Museum Services, Sunderland +
19. Swansea Museum*
20. Yorkshire Museum, York

University Museums

21. Museum of the Department of Zoology, University of Aberdeen +
22. Museum of the Department of Geological Sciences, University of Birmingham*
23. Sedgwick Museum, Cambridge (included in the return from the University of Cambridge)
24. University Museum of Zoology, Cambridge (included in the return from the University of Cambridge)
25. Hunterian Museum, University of Glasgow +
26. The Manchester Museum, University of Manchester
27. Hancock Museum, University of Newcastle
28. Museum of the Department of Geography and Earth Science, Queen Mary and Westfield College, University of London*
29. University Museum, Oxford (included in the return from the University of Oxford)
30. Cole Museum of Zoology, University of Reading (included in the return from the University of Reading)

National Botanic Gardens

31. Royal Botanic Gardens, Kew
32. Royal Botanic Gardens, Edinburgh

Local Authority/Regional Botanic Gardens

33. St. Andrews Botanic Garden (formerly The University Botanic Garden)
34. Botanic Gardens, Glasgow +

University Botanic Gardens

35. Cruickshank Botanic Garden, University of Aberdeen +
36. University of Leicester Botanic Gardens*
37. Liverpool University Botanic Gardens, Ness*
38. University of London Botanic Gardens, Egham*
39. University of Oxford Botanic Garden

University Departments

40. University of Aberdeen
41. The University College of Wales, Aberystwyth
42. University College of North Wales, Bangor
43. University of Bath
44. Queen's University Belfast
45. University of Birmingham
46. University of Bradford*
47. University of Bristol
48. Brunel University
49. University of Cambridge (including the Sedgwick Museum, the University Museum of Zoology, and the University Botanic Garden)
50. The University of Wales College of Cardiff
51. University of Dundee
52. University of Durham
53. University of East Anglia
54. The University of Edinburgh
55. University of Essex
56. University of Exeter
57. University of Glasgow
58. Heriot-Watt University
59. University of Hull
60. University of Keele
61. University of Kent
62. University of Lancaster*
63. University of Leeds
64. University of Leicester
65. University of Liverpool
66. The Institute of Zoology, The Zoological Society, University of London
67. Imperial College of Science and Technology, University of London
68. King's College, University of London
69. Queen Mary & Westfield College, University of London
70. Royal Holloway & Bedford New College, University of London
71. University College London
72. Wye College, University of London
73. The University of Technology, Loughborough*
74. University of Manchester
75. UMIST
76. University of Newcastle
77. University of Nottingham
78. The Open University +
79. University of Oxford (including the University Museum)
80. University of Reading (including the Cole Museum of Zoology)
81. University of St. Andrews
82. University of Salford
83. University of Sheffield (including the Unit of Comparative Plant Ecology)
84. University of Southampton
85. University of Stirling (including the Unit of Aquatic Biochemistry)
86. University of Strathclyde +
87. University of Surrey
88. University of Sussex
89. University College of Swansea
90. University of Warwick +
91. University of York

Polytechnics/Other HEIs

92. Brighton Polytechnic*
93. Bristol Polytechnic*
94. Coventry Polytechnic*
95. Kingston Polytechnic*
96. Lancashire Polytechnic
97. Leeds Polytechnic*
98. Liverpool Polytechnic
99. Polytechnic of East London
100. Nottingham Polytechnic
101. Paisley College*
102. Portsmouth Polytechnic
103. Polytechnic South West, Plymouth*
104. Sheffield Polytechnic +
105. Sunderland Polytechnic +
106. Thames Polytechnic*
107. Wolverhampton Polytechnic*

Research Council Institutes/Laboratories

108. AFRC Institute of Animal Physiology and Genetics Research, Cambridge and Edinburgh
109. AFRC Institute of Food Research, Reading
110. AFRC Institute of Plant Science Research, John Innes Institute, Norwich
111. AFRC Institute of Grassland and Environmental Research, Aberystwyth
112. AFRC Institute of Arable Crop Research, Harpenden
113. Hannah Research Institute, Ayr +
114. Moredun Research Institute, Edinburgh*
115. Macaulay Land Use Research Institute, Aberdeen
116. Rowett Research Institute, Aberdeen
117. Scottish Crop Research Institute, Dundee
118. British Geological Survey
119. British Antarctic Survey
120. Centre for Population Biology, Imperial College +
121. Dunstaffnage Marine Laboratory, Oban (incorporating the Scottish Marine Biological Association)
122. Institute of Freshwater Ecology/Freshwater Biological Association
123. Institute of Oceanographic Sciences Deacon Laboratory, Godalming
124. Institute of Terrestrial Ecology, Huntingdon and Penicuik
125. Institute of Virology and Environmental Microbiology, Oxford
126. Plymouth Marine Laboratory (incorporating the Marine Biological Association)
127. Sea Mammal Research Unit, Cambridge
128. Unit of Comparative Plant Ecology, University of Sheffield
129. Unit of Aquatic Biochemistry, University of Stirling
130. National Institute for Medical Research

Government Departments/Agencies

131. Department of the Environment (Central Divisions)
132. Forestry Commission
133. MAFF (incorporating the Central Science Laboratories, Harpenden and Slough, and the Central Veterinary Laboratory, Weybridge)
134. MoD: Chemical Defence Research Establishment, Porton Down +
135. ODA: ODNRI
136. Public Health Laboratory Service (National Collection of Type Cultures)
137. Scottish Office Agriculture and Fisheries Department (Agricultural Scientific Services)

Other Organisations

138. British Ecological Society*
139. CAB International
140. Chelsea Physic Garden

-
141. Fish Conservation Centre, Stirling
 142. Horticultural Research International, Maidstone
 143. Joint Nature Conservation Committee
 144. Linnean Society
 145. National Institute of Agricultural Botany, Cambridge
 146. National Rivers Authority
 147. Royal Entomological Society*
 148. Royal Horticultural Society
 149. Royal Society for the Protection of Birds +
 150. Water Resources Centre plc +
 151. Wildfowl and Wetland Trust*
 152. World Conservation Monitoring Centre, Cambridge*

ANNEX 4 - DATA FOR 1980

TABLE 4A: Expenditure on Systematic Biology (£'000 - 1980 prices)

Category of Performer	1980 Expenditure (£'000 - 1980 Prices)											
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	Total (£'000)	%
TABLE 4A: Expenditure on Systematic biology (£'000 - 1980 prices)												
Q1. What was your total expenditure on systematic biology?												
Total Expenditure (£'000)	5621.0	127.7	106.9	2161.0	121.0	2561.8	38.0	2618.8	1448.0	1446.3	16250.4	
Q2. What proportions of this total were devoted to:												
(a) Research (£'000)	3150.0	19.4	33.2	1043.2	2.8	1958.9	24.3	2271.7	659.3	363.8	9526.5	58.6
(b) Curation (£'000)	1344.4	74.8	56.9	779.2	4.8	390.3	0.1	152.0	416.3	314.7	3533.3	21.7
(c) Information Services (£'000)	843.7	19.5	16.6	338.5	8.0	66.3	0.0	195.2	264.1	167.4	1919.4	11.8
(d) Other Activities (£'000)	282.9	13.9	0.2	0.0	105.5	146.3	13.6	0.0	108.2	600.5	1271.1	7.8
	5621.0	127.7	106.9	2161.0	121.0	2561.8	38.0	2618.8	1448.0	1446.3	16250.4	100.0
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:												
(a) Salaries (£'000)	2752.2	14.4	13.3	793.7	2.8	1571.1	14.1	1367.9	347.8	248.3	7125.6	74.8
(b) Equipment (£'000)	130.5	1.6	5.0	91.3	0.0	113.9	1.5	204.9	158.4	19.9	726.8	7.6
(c) General Overheads (£'000)	12.4	3.2	14.9	91.3	0.0	246.9	1.5	675.7	142.3	93.6	1281.7	13.5
(d) Other Activities (£'000)	255.0	0.3	0.0	67.0	0.0	27.0	7.2	23.1	10.9	2.1	392.4	4.1
	3150.0	19.4	33.2	1043.2	2.8	1958.9	24.3	2271.7	659.3	363.8	9526.5	100.0
Q4. What were the main sources of funding for your research in systematic biology?												
(a) Core Funding (£'000)	2547.5	16.0	33.2	1023.7	2.8	1141.4	3.6	888.5	578.4	0.0	6234.9	65.4
(b) Research Councils (£'000)	300.0	0.0	0.0	2.2	0.0	331.1	10.9	1114.0	0.0	46.2	1804.4	18.9
(c) Government Departments (£'000)	0.0	3.2	0.0	3.2	0.0	342.6	1.1	167.2	0.0	128.8	646.0	6.8
(d) Commercial organisations (£'000)	150.0	0.0	0.0	4.7	0.0	47.0	7.7	0.0	0.0	3.4	212.8	2.2
(e) Self-generated income (£'000)	90.0	0.0	0.0	0.0	0.0	10.9	1.0	102.0	72.5	97.3	373.7	3.9
(f) Other (£'000)	62.5	0.2	0.0	9.5	0.0	85.9	0.0	0.0	8.4	88.1	254.6	2.7
	3150.0	19.4	33.2	1043.2	2.8	1958.9	24.3	2271.7	659.3	363.8	9526.5	100.0
Q5. What was your total manpower engaged in systematic biology?												
Total manpower (Man Years)	384.3	13.6	8.0	174.5	5.6	182.4	3.8	132.2	45.3	175.1	1124.8	MnYrs
Q6. What proportions of this manpower were devoted to:												
(a) Research (Man Years)	148.9	2.4	1.4	77.7	0.3	135.9	2.7	112.1	15.9	54.4	551.5	49.0
(b) Curation (Man Years)	143.6	7.1	5.1	78.5	0.8	32.6	0.0	13.0	11.2	26.7	318.7	28.3
(c) Information Services (Man Years)	57.8	3.4	1.4	18.3	4.5	10.6	0.0	7.1	9.1	19.5	131.8	11.7
(d) Other Activities (Man Years)	34.0	0.6	0.1	0.0	0.0	3.3	1.2	0.0	9.1	74.5	122.8	10.9
	384.3	13.6	8.0	174.5	5.6	182.4	3.8	132.2	45.3	175.1	1124.8	100.0

TABLE 4A: *Expenditure on Systematic Biology (£'000 - 1980 prices)*—cont.

Category of Performer	1980 Expenditure (£'000 - 1980 Prices									Total (£'000)	%	
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts			
Q7. What proportions of the research manpower in 6(a) above were employed:												
(a) Permanently	147.5	2.4	1.4	76.5	0.3	102.3	0.9	103.9	15.9	499.8	90.6	
(b) On fixed term contracts	1.4	0.0	0.0	1.2	0.0	33.6	1.7	8.2	0.0	51.8	9.4	
	148.9	2.4	1.4	77.7	0.3	135.9	2.7	112.1	15.9	551.5	100.0	
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?												
(a) No. Systematists (Man Years)	311.0	1.9	0.0	92.5	0.0	228.7	16.0	85.5	35.2	822.8		
(b) No. Involved in Teaching (Man Years)	3.2	0.1	0.0	18.0	0.1	156.7	15.0	3.1	4.5	215.0	26.1	
(c) No. Supervising Research Students (Man Years)	12.1	0.0	0.0	27.0	0.0	101.9	8.0	16.5	3.0	168.5	20.5	
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?												
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	16.8	19.3	0.0	0.0	17.1		
Q10. How many postgraduate research students were studying systematic biology in your organisation?												
No. PG research students	15.0	1.0	0.0	11.0	1.0	196.0	6.0	20.0	4.0	255.0	Number	
Q11. What was the age distribution of your staff teaching systematic biology?												
(a) 35 and under	0.0	0.0	0.0	0.0	0.0	62.0	1.0	8.0	3.0	74.0	24.4	
(b) 36-45	1.0	1.0	0.0	4.0	0.0	80.9	7.0	4.0	4.0	101.9	33.6	
(c) 46-55	1.0	0.0	0.0	0.0	1.0	76.5	1.0	7.0	1.0	87.5	28.8	
(d) 56-65	0.0	0.0	0.0	0.0	0.0	32.9	3.0	0.0	0.0	35.9	11.8	
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	4.0	1.3	
	2.0	1.0	0.0	4.0	1.0	256.3	12.0	19.0	8.0	303.3	100.0	

TABLE 4B: Expenditure on Systematic Biology (£'000 - 1990 prices)

Category of Performer	1980 Expenditure (£'000 - 1990 Prices)										% Total (£'000)
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	
Q1. What was your total expenditure on systematic biology?											
Total Expenditure (£'000)	10342.6	234.9	196.7	3976.2	222.6	4713.7	69.9	4818.6	2664.3	2661.1	29900.7
Q2. What proportions of this total were devoted to:											
(a) Research (£'000)	5795.9	35.7	61.1	1919.5	5.1	3604.4	44.7	4179.9	1213.2	669.3	17528.8
(b) Curation (£'000)	2473.8	137.6	104.6	1433.8	8.8	718.1	0.2	279.6	765.9	579.0	6501.4
(c) Information Services (£'000)	1552.5	35.9	30.5	622.9	14.7	122.1	0.0	359.1	486.0	308.0	3531.7
(d) Other Activities (£'000)	520.5	25.6	0.4	0.0	194.0	269.2	25.1	0.0	199.2	1104.9	2338.9
	10342.6	234.9	196.7	3976.2	222.6	4713.7	69.9	4818.6	2664.3	2661.1	29900.7
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:											
(a) Salaries (£'000)	5064.0	26.5	24.4	1460.5	5.1	2890.9	25.9	2517.0	640.0	456.8	13111.1
(b) Equipment (£'000)	240.0	2.9	9.2	167.9	0.0	209.5	2.8	377.0	291.4	36.5	1337.3
(c) General Overheads (£'000)	22.7	5.8	27.5	167.9	0.0	454.4	2.8	1243.3	261.8	172.2	2358.4
(d) Other Activities (£'000)	469.2	0.5	0.0	123.2	0.0	49.6	13.2	42.5	20.0	3.8	722.0
	5795.9	35.7	61.1	1919.5	5.1	3604.4	44.7	4179.9	1213.2	669.3	17528.8
Q4. What were the main sources of funding for your research in systematic biology?											
(a) Core Funding (£'000)	4687.3	29.5	61.1	1883.6	5.1	2100.2	6.6	1634.8	1064.2	0.0	11472.3
(b) Research Councils (£'000)	552.0	0.0	0.0	4.1	0.0	609.3	20.1	2049.8	0.0	85.0	3320.2
(c) Government Departments (£'000)	0.0	5.8	0.0	5.8	0.0	630.4	2.1	307.7	0.0	236.9	1188.7
(d) Commercial organisations (£'000)	276.0	0.0	0.0	8.7	0.0	86.5	14.1	0.0	0.0	6.3	391.6
(e) Self-generated income (£'000)	165.6	0.0	0.0	0.0	0.0	20.1	1.8	187.7	133.4	179.0	687.6
(f) Other (£'000)	115.0	0.4	0.0	17.4	0.0	158.0	0.0	0.0	15.5	162.1	468.5
	5795.9	35.7	61.1	1919.5	5.1	3604.4	44.7	4179.9	1213.1	669.3	17528.8
Q5. What was your total manpower engaged in systematic biology?											
Total manpower (Man Years)	384.3	13.6	8.0	174.5	5.6	182.4	3.8	132.2	45.3	175.1	1124.8
Q6. What proportions of this manpower were devoted to:											
(a) Research (Man Years)	148.9	2.4	1.4	77.7	0.3	135.9	2.7	112.1	15.9	54.4	551.5
(b) Curation (Man Years)	143.6	7.1	5.1	78.5	0.8	32.6	0.0	13.0	11.2	26.7	318.7
(c) Information Services (Man Years)	57.8	3.4	1.4	18.3	4.5	10.6	0.0	7.1	9.1	19.5	131.8
(d) Other Activities (Man Years)	34.0	0.6	0.1	0.0	0.0	3.3	1.2	0.0	9.1	74.5	122.8
	384.3	13.6	8.0	174.5	5.6	182.4	3.8	132.2	45.3	175.1	1124.8

MnYrs

TABLE 4C: *Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Total Expenditure)*

Category of Performer	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	Sum (%)	Total (£'000)
Q1. What was your total expenditure on systematic biology? Total Expenditure (%)	34.6	0.8	0.7	13.3	0.7	15.8	0.2	16.1	8.9	8.9	100.0	29900.7
Q2. What proportions of this total were devoted to:												
(a) Research (%)	33.1	0.2	0.3	11.0	0.0	20.6	0.3	23.8	6.9	3.8	100.0	17528.8
(b) Curation (%)	38.1	2.1	1.6	22.1	0.1	11.0	0.0	4.3	11.8	8.9	100.0	6501.4
(c) Information Services (%)	44.0	1.0	0.9	17.6	0.4	3.5	0.0	10.2	13.8	8.7	100.0	3531.7
(d) Other Activities (%)	22.3	1.1	0.0	0.0	8.3	11.5	1.1	0.0	8.5	47.2	100.0	2338.8
	34.6	0.8	0.7	13.3	0.7	15.8	0.2	16.1	8.9	8.9	100.0	29900.7
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:												
(a) Salaries (%)	38.6	0.2	0.2	11.1	0.0	22.0	0.2	19.2	4.9	3.5	100.0	13111.1
(b) Equipment (%)	17.9	0.2	0.7	12.6	0.0	15.7	0.2	28.2	21.8	2.7	100.0	1337.3
(c) General Overheads (%)	1.0	0.2	1.2	7.1	0.0	19.3	0.1	52.7	11.1	7.3	100.0	2358.4
(d) Other Activities (%)	65.0	0.1	0.0	17.1	0.0	6.9	1.8	5.9	2.8	0.5	100.0	722.0
	33.1	0.2	0.3	11.0	0.0	20.6	0.3	23.8	6.9	3.8	100.0	17528.8
Q4. What were the main sources of funding for your research in systematic biology?												
(a) Core Funding (%)	40.9	0.3	0.5	16.4	0.0	18.3	0.1	14.2	9.3	0.0	100.0	11472.3
(b) Research Councils (%)	16.6	0.0	0.0	0.1	0.0	18.4	0.6	61.7	0.0	2.6	100.0	3320.2
(c) Government Departments (%)	0.0	0.5	0.0	0.5	0.0	53.0	0.2	25.9	0.0	19.9	100.0	1188.7
(d) Commercial organisations (%)	70.5	0.0	0.0	2.2	0.0	22.1	3.6	0.0	0.0	1.6	100.0	391.6
(e) Self-generated income (%)	24.1	0.0	0.0	0.0	0.0	2.9	0.3	27.3	19.4	26.0	100.0	687.6
(f) Other (%)	24.5	0.1	0.0	3.7	0.0	33.7	0.0	0.0	3.3	34.6	100.0	468.5
	33.1	0.2	0.3	11.0	0.0	20.6	0.3	23.8	6.9	3.8	100.0	17528.8
Q5. What was your total manpower engaged in systematic biology? Total manpower (%)	34.2	1.2	0.7	15.5	0.5	16.2	0.3	11.8	4.0	15.6	100.0	1124.8
Q6. What proportions of this manpower were devoted to:												
(a) Research (%)	27.0	0.4	0.3	14.1	0.1	24.6	0.5	20.3	2.9	9.9	100.0	551.5
(b) Curation (%)	45.1	2.2	1.6	24.6	0.3	10.2	0.0	4.1	3.5	8.4	100.0	318.7
(c) Information Services (%)	43.8	2.6	1.1	13.9	3.4	8.0	0.0	5.4	6.9	14.8	100.0	131.8
(d) Other Activities (%)	27.7	0.5	0.1	0.0	0.0	2.7	0.9	0.0	7.4	60.6	100.0	122.8
	34.2	1.2	0.7	15.5	0.5	16.2	0.3	11.8	4.0	15.6	100.0	1124.8

TABLE 4D: Expenditure on Systematic Biology (Performer expenditure as a Per Cent of Own Expenditure)

[illegible]

TABLE 4D: Expenditure on Systematic Biology (Performer expenditure as a Per Cent of Own Expenditure)—cont.

Category of Performer	1980 Expenditure (Per Cent)									
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other
Q7. What proportion of the research manpower in 6(a) above were employed:										
(a) Permanently (%)	99.1	100.0	100.0	98.5	100.0	75.3	35.7	92.7	100.0	89.6
(b) On fixed term contracts (%)	0.9	0.0	0.0	1.5	0.0	24.7	64.3	7.3	0.0	10.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?										
(a) No. Systematists (Man Years)	311.0	1.9	0.0	92.5	0.0	228.7	16.0	85.5	35.2	52.0
(b) No. Involved in Teaching as % of (a)	1.0	2.7	0.0	19.5	0.0	68.5	93.8	3.6	12.8	27.6
(c) No. Supervising Research Students as % of (a)	3.9	0.0	0.0	29.2	0.0	44.5	50.0	19.3	8.5	0.0
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?										
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	16.8	19.3	0.0	0.0	0.0
Q10. How many postgraduate research students were studying systematic biology in your organisation?										
No. PG research students	15.0	1.0	0.0	11.0	1.0	196.0	6.0	20.0	4.0	1.0
Q11. What was the age distribution of your staff teaching systematic biology?										
(a) 35 and under	0.0	0.0	0.0	0.0	0.0	24.2	8.3	42.1	37.5	0.0
(b) 36-45	50.0	100.0	0.0	100.0	0.0	31.6	58.3	21.1	50.0	0.0
(c) 46-55	50.0	0.0	0.0	0.0	100.0	29.8	8.3	36.8	12.5	0.0
(d) 56-65	0.0	0.0	0.0	0.0	0.0	12.8	25.0	0.0	0.0	0.0
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0
	100.0	100.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
										100.0

Number
255.0

Q11. What was the age distribution of your staff teaching systematic biology?

24.4
33.6
28.8
11.8
1.3

ANNEX 5 - DATA FOR 1985

TABLE 5A: Expenditure on Systematic Biology (£'000 - 1985 prices)

Category of Performer	1985 Expenditure (£'000 - 1985 Prices)										% Total (£'000)
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	
Q1. What was your total expenditure on systematic biology?											
Total Expenditure (£'000)	7706.5	151.7	149.8	2828.0	166.0	3146.9	102.3	3223.6	2062.8	2196.0	21733.7
Q2. What proportions of this total were devoted to:											
(a) Research (£'000)	4195.1	18.2	36.6	1349.0	3.9	2288.6	83.5	2835.0	882.8	690.9	12383.7
(b) Curation (£'000)	1880.8	83.5	82.1	1041.0	5.9	551.4	0.4	185.8	588.7	474.3	4893.9
(c) Information Services (£'000)	1239.0	23.5	30.5	437.9	8.0	95.9	0.0	202.8	402.1	239.8	2679.5
(d) Other Activities (£'000)	391.6	26.5	0.6	0.0	148.2	211.0	18.4	0.0	189.2	791.1	1776.6
	7706.5	151.7	149.8	2828.0	166.0	3146.9	102.3	3223.6	2062.8	2196.0	21733.7
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:											
(a) Salaries (£'000)	3716.5	14.6	18.3	1082.1	3.9	1853.6	61.0	1761.3	451.3	449.7	9412.2
(b) Equipment (£'000)	214.2	1.1	3.7	80.9	0.0	150.5	10.5	216.7	217.3	36.4	931.4
(c) General Overheads (£'000)	29.5	2.4	14.6	120.9	0.0	246.8	2.9	824.0	207.0	198.3	1646.5
(d) Other Activities (£'000)	234.9	0.1	0.0	65.1	0.0	37.7	9.1	33.0	7.2	6.5	393.5
	4195.1	18.2	36.6	1349.0	3.9	2288.6	83.5	2835.0	882.8	690.9	12383.7
Q4. What were the main sources of funding for your research in systematic biology?											
(a) Core Funding (£'000)	4071.4	16.7	36.6	1310.0	3.9	1272.0	10.5	1127.0	653.6	0.0	8501.8
(b) Research Councils (£'000)	48.5	0.0	0.0	3.0	0.0	475.4	46.2	1056.8	0.0	97.1	1726.9
(c) Government Departments (£'000)	40.6	1.2	0.0	16.7	0.0	298.8	0.0	541.3	162.5	239.4	1300.4
(d) Commercial organisations (£'000)	14.0	0.0	0.0	6.5	0.0	81.0	8.0	49.0	0.0	2.6	161.0
(e) Self-generated income (£'000)	16.3	0.0	0.0	0.0	0.0	12.7	18.8	61.0	33.8	178.4	321.0
(f) Other (£'000)	4.3	0.3	0.0	12.9	0.0	148.8	0.0	0.0	32.8	173.4	372.5
	4195.1	18.2	36.6	1349.0	3.9	2288.6	83.5	2835.0	882.8	690.9	12383.7
Q5. What was your total manpower engaged in systematic biology?											
Total manpower (Man Years)	381.4	11.2	7.5	171.5	4.6	165.3	5.6	126.9	44.3	182.8	1101.1
Q6. What proportions of this manpower were devoted to:											
(a) Research (Man Years)	155.0	1.9	1.2	78.2	0.3	123.2	4.8	110.1	13.0	59.0	546.7
(b) Curation (Man Years)	136.8	5.6	5.0	75.2	0.7	32.2	0.2	9.4	12.5	28.8	306.3
(c) Information Services (Man Years)	58.3	2.4	1.2	18.2	3.6	5.2	0.0	7.5	8.3	19.0	123.6
(d) Other Activities (Man Years)	31.3	1.2	0.2	0.0	0.0	4.7	0.6	0.0	10.4	76.1	124.6
	381.4	11.2	7.5	171.5	4.6	165.3	5.6	126.9	44.3	182.8	1101.1

MnYrs

TABLE 5A: Expenditure on Systematic Biology (£'000 - 1985 prices)—cont.

Category of Performer	1985 Expenditure (£'000 - 1985 Prices)										Total (£'000)	%
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other		
Q7. What proportions of the research manpower in 6(a) above were employed:												
(a) Permanently	146.9	1.9	1.2	76.5	0.3	80.5	0.8	95.8	11.7	48.6	464.3	84.9
(b) On fixed term contracts	8.1	0.0	0.0	1.7	0.0	42.8	3.9	14.3	1.3	10.4	82.4	15.1
	155.0	1.9	1.2	78.2	0.3	123.2	4.8	110.1	13.0	59.0	546.7	100.0
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?												
(a) No. Systematists (Man Years)	308.0	1.7	0.0	92.5	0.0	201.6	18.0	87.0	35.4	54.0	798.1	
(b) No. Involved in Teaching (Man Years)	4.3	0.0	0.0	19.0	0.1	135.2	14.0	2.8	4.5	30.6	210.5	26.4
(c) No. Supervising Research Students (Man Years)	17.2	0.0	0.0	27.0	0.0	83.4	8.0	22.6	3.0	0.0	161.2	20.2
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?												
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	12.6	11.2	0.0	0.0	0.0	12.4	
Q10. How many postgraduate research students were studying systematic biology in your organisation?												
No. PG research students	32.0	1.0	0.0	12.0	1.0	170.6	7.0	29.0	4.0	1.0	257.6	
Q11. What was the age distribution of your staff teaching systematic biology?												
(a) 35 and under	2.0	0.0	0.0	1.0	0.0	28.1	1.0	6.0	1.0	5.0	44.1	14.9
(b) 36-45	3.0	1.0	0.0	3.0	0.0	78.7	8.0	7.0	4.0	7.0	111.7	37.7
(c) 46-55	3.0	0.0	0.0	1.0	0.0	69.1	2.0	3.0	3.0	10.0	91.1	30.7
(d) 56-65	0.0	0.0	0.0	0.0	1.0	39.6	0.0	0.0	0.0	7.0	47.6	16.1
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0	0.7
	8.0	1.0	0.0	5.0	1.0	217.5	11.0	16.0	8.0	29.0	296.5	100.0

TABLE 5B: Expenditure on Systematic Biology (£'000 - 1990 prices)

Category of Performer	1985 Expenditure (£'000 - 1990 Prices)										% Total (£'000)
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	
Q1. What was your total expenditure on systematic biology?											
Total Expenditure (£'000)	10157.2	200.0	197.4	3727.3	218.8	4147.6	134.8	4248.8	2718.8	2894.3	28645.0
Q2. What proportions of this total were devoted to:											
(a) Research (£'000)	5529.2	24.0	48.2	1778.0	5.1	3016.4	110.1	3736.5	1163.5	910.6	16321.7
(b) Curation (£'000)	2478.9	110.1	108.2	1372.1	7.8	726.7	0.5	244.9	775.9	625.1	6450.1
(c) Information Services (£'000)	1632.9	31.0	40.2	577.2	10.5	126.4	0.0	267.3	530.0	316.0	3531.6
(d) Other Activities (£'000)	516.2	34.9	0.7	0.0	195.3	278.2	24.3	0.0	249.4	1042.6	2341.6
	10157.2	200.0	197.4	3727.3	218.8	4147.6	134.8	4248.8	2718.8	2894.3	28645.0
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:											
(a) Salaries (£'000)	4898.4	19.2	24.1	1426.1	5.1	2443.1	80.4	2321.3	594.7	592.7	12405.3
(b) Equipment (£'000)	282.3	1.5	4.8	106.7	0.0	198.4	13.8	285.6	286.4	48.0	1227.5
(c) General Overheads (£'000)	38.9	3.2	19.3	159.4	0.0	325.2	3.8	1086.0	272.9	261.4	2170.1
(d) Other Activities (£'000)	309.5	0.1	0.0	85.8	0.0	49.6	12.0	43.5	9.5	8.5	518.7
	5529.2	24.0	48.2	1778.0	5.1	3016.4	110.1	3736.5	1163.5	910.6	16321.7
Q4. What were the main sources of funding for your research in systematic biology?											
(a) Core Funding (£'000)	5366.2	22.0	48.2	1726.6	5.1	1676.5	13.9	1485.3	861.4	0.0	11205.3
(b) Research Councils (£'000)	64.0	0.0	0.0	4.0	0.0	626.5	60.8	1392.8	0.0	128.0	2276.1
(c) Government Departments (£'000)	53.4	1.6	0.0	22.0	0.0	393.8	0.0	713.4	214.2	315.5	1713.9
(d) Commercial organisations (£'000)	18.4	0.0	0.0	8.5	0.0	106.7	10.5	64.6	0.0	3.5	212.2
(e) Self-generated income (£'000)	21.5	0.0	0.0	0.0	0.0	16.7	24.8	80.4	44.6	235.1	423.1
(f) Other (£'000)	5.7	0.4	0.0	17.0	0.0	196.1	0.0	0.0	43.2	228.6	491.0
	5529.2	24.0	48.2	1778.0	5.1	3016.4	110.1	3736.5	1163.5	910.6	16321.7
Q5. What was your total manpower engaged in systematic biology?											
Total manpower (Man Years)	381.4	11.2	7.5	171.5	4.6	165.3	5.6	126.9	44.3	182.8	1101.1
Q6. What proportions of this manpower were devoted to:											
(a) Research (Man Years)	155.0	1.9	1.2	78.2	0.3	123.2	4.8	110.1	13.0	59.0	546.7
(b) Curation (Man Years)	136.8	5.6	5.0	75.2	0.7	32.2	0.2	9.4	12.5	28.8	306.3
(c) Information Services (Man Years)	58.3	2.4	1.2	18.2	3.6	5.2	0.0	7.5	8.3	19.0	123.6
(d) Other Activities (Man Years)	31.3	1.2	0.2	0.0	0.0	4.7	0.6	0.0	10.4	76.1	124.6
	381.4	11.2	7.5	171.5	4.6	165.3	5.6	126.9	44.3	182.8	1101.1

MnYrs

TABLE 5B: Expenditure on Systematic Biology (£'000 - 1990 prices)—cont.

Category of Performer	1985 Expenditure (£'000 - 1990 Prices)										Total (£'000)	%
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other		
Q7. What proportions of the research manpower in 6(a) above were employed:												
(a) Permanently	146.9	1.9	1.2	76.5	0.3	80.5	0.8	95.8	11.7	48.6	464.3	84.9
(b) On fixed term contracts	8.1	0.0	0.0	1.7	0.0	42.8	3.9	14.3	1.3	10.4	82.4	15.1
	155.0	1.9	1.2	78.2	0.3	123.2	4.8	110.1	13.0	59.0	546.7	100.0
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?												
(a) No. Systematists (Man Years)	308.0	1.7	0.0	92.5	0.0	201.6	18.0	87.0	35.4	54.0	798.1	
(b) No. Involved in Teaching (Man Years)	4.3	0.0	0.0	19.0	0.1	135.2	14.0	2.8	4.5	30.6	210.5	26.4
(c) No. Supervising Research Students (Man Years)	17.2	0.0	0.0	27.0	0.0	83.4	8.0	22.6	3.0	0.0	161.2	20.2
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?												
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	12.6	11.2	0.0	0.0	0.0	12.4	
Q10. How many postgraduate research students were studying systematic biology in your organisation?												
No. PG research students	32.0	1.0	0.0	12.0	1.0	170.6	7.0	29.0	4.0	1.0	257.6	
Q11. What was the age distribution of your staff teaching systematic biology?												
(a) 35 and under	2.0	0.0	0.0	1.0	0.0	28.1	1.0	6.0	1.0	5.0	44.1	14.9
(b) 36-45	3.0	1.0	0.0	3.0	0.0	78.7	8.0	7.0	4.0	7.0	111.7	37.7
(c) 46-55	3.0	0.0	0.0	1.0	0.0	69.1	2.0	3.0	3.0	10.0	91.1	30.7
(d) 56-65	0.0	0.0	0.0	0.0	1.0	39.6	0.0	0.0	0.0	7.0	47.6	16.1
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0	0.7
	8.0	1.0	0.0	5.0	1.0	217.5	11.0	16.0	8.0	29.0	296.5	100.0

TABLE 5C: Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Total Expenditure)

Category of Performer	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	Sum (%)	Total (£'000)
1985 Expenditure (Per Cent)												
Q1. What was your total expenditure on systematic biology?	35.5	0.7	0.7	13.0	0.8	14.5	0.5	14.8	9.5	10.1	100.0	28645.0
Total Expenditure (%)												
Q2. What proportions of this total were devoted to:												
(a) Research (%)	33.9	0.1	0.3	10.9	0.0	18.5	0.7	22.9	7.1	5.6	100.0	16321.7
(b) Curation (%)	38.4	1.7	1.7	21.3	0.1	11.3	0.0	3.8	12.0	9.7	100.0	6450.1
(c) Information Services (%)	46.2	0.9	1.1	16.3	0.3	3.6	0.0	7.6	15.0	8.9	100.0	3531.6
(d) Other Activities (%)	22.0	1.5	0.0	0.0	8.3	11.9	1.0	0.0	10.7	44.5	100.0	2341.6
	35.5	0.7	0.7	13.0	0.8	14.5	0.5	14.8	9.5	10.1	100.0	28645.0
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:												
(a) Salaries (%)	39.5	0.2	0.2	11.5	0.0	19.7	0.6	18.7	4.8	4.8	100.0	12405.3
(b) Equipment (%)	23.0	0.1	0.4	8.7	0.0	16.2	1.1	23.3	23.3	3.9	100.0	1227.5
(c) General Overheads (%)	1.8	0.1	0.9	7.3	0.0	15.0	0.2	50.0	12.6	12.0	100.0	2170.1
(d) Other Activities (%)	59.7	0.0	0.0	16.5	0.0	9.6	2.3	8.4	1.8	1.6	100.0	518.7
	33.9	0.1	0.3	10.9	0.0	18.5	0.7	22.9	7.1	5.6	100.0	16321.7
Q4. What were the main sources of funding for your research in systematic biology?												
(a) Core Funding (%)	47.9	0.2	0.4	15.4	0.0	15.0	0.1	13.3	7.7	0.0	100.0	11205.3
(b) Research Councils (%)	2.8	0.0	0.0	0.2	0.0	27.5	2.7	61.2	0.0	5.6	100.0	2276.1
(c) Government Departments (%)	3.1	0.1	0.0	1.3	0.0	23.0	0.0	41.6	12.5	18.4	100.0	1713.9
(d) Commercial organisations (%)	8.7	0.0	0.0	4.0	0.0	50.3	5.0	30.4	0.0	1.6	100.0	212.2
(e) Self-generated income (%)	5.1	0.0	0.0	0.0	0.0	4.0	5.9	19.0	10.5	55.6	100.0	423.1
(f) Other (%)	1.2	0.1	0.0	3.5	0.0	39.9	0.0	0.0	8.8	46.6	100.0	491.0
	33.9	0.1	0.3	10.9	0.0	18.5	0.7	22.9	7.1	5.6	100.0	16321.7
Q5. What was your total manpower engaged in systematic biology?												
Total manpower (%)	34.6	1.0	0.7	15.6	0.4	15.0	0.5	11.5	4.0	16.6	100.0	1101.1
Q6. What proportions of this manpower were devoted to:												
(a) Research (%)	28.4	0.4	0.2	14.3	0.1	22.5	0.9	20.1	2.4	10.8	100.0	546.7
(b) Curation (%)	44.7	1.8	1.6	24.5	0.2	10.5	0.1	3.1	4.1	9.4	100.0	306.3
(c) Information Services (%)	47.2	2.0	1.0	14.7	2.9	4.2	0.0	6.0	6.7	15.3	100.0	123.6
(d) Other Activities (%)	25.2	1.0	0.1	0.0	0.0	3.8	0.5	0.0	8.4	61.1	100.0	124.6
	34.6	1.0	0.7	15.6	0.4	15.0	0.5	11.5	4.0	16.6	100.0	1101.1

TABLE 5C: *Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Total Expenditure)*—cont.

Category of Performer	1985 Expenditure (Per Cent)											
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other	Sum (%)	Total (£'000)
Q7. What proportions of the research manpower in 6(a) above were employed:												
(a) Permanently (%)	31.6	0.4	0.3	16.5	0.1	17.3	0.2	20.6	2.5	10.5	100.0	464.3
(b) On fixed term contracts (%)	9.8	0.0	0.0	2.0	0.0	51.9	4.8	17.3	1.6	12.6	100.0	82.4
	28.4	0.4	0.2	14.3	0.1	22.5	0.9	20.1	2.4	10.8	100.0	546.7
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?												
(a) No. Systematists (% of Total Manpower)	38.6	0.2	0.0	11.6	0.0	25.3	2.3	10.9	4.4	6.8	100.0	798.1
(b) No. Involved in Teaching (% of Systematists)	2.1	0.0	0.0	9.0	0.1	64.2	6.7	1.3	2.1	14.5	100.0	210.5
(c) No. Supervising Research Students (% of Systematists)	10.6	0.0	0.0	16.8	0.0	51.7	5.0	14.0	1.9	0.0	100.0	161.2
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?												
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	12.6	11.2	0.0	0.0	0.0	12.4	
Q10. How many postgraduate research students were studying systematic biology in your organisation?												
No. PG research students	12.4	0.4	0.0	4.7	0.4	66.2	2.7	11.3	1.6	0.4	100.0	Number 257.6
Q11. What was the age distribution of your staff teaching systematic biology?												
(a) 35 and under	4.5	0.0	0.0	2.3	0.0	63.7	2.3	13.6	2.3	11.3	100.0	44.1
(b) 36-45	2.7	0.9	0.0	2.7	0.0	70.5	7.2	6.3	3.6	6.3	100.0	111.7
(c) 46-55	3.3	0.0	0.0	1.1	0.0	75.9	2.2	3.3	3.3	11.0	100.0	91.1
(d) 56-65	0.0	0.0	0.0	0.0	2.1	83.2	0.0	0.0	0.0	14.7	100.0	47.6
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	2.0
	2.7	0.3	0.0	1.7	0.3	73.4	3.7	5.4	2.7	9.8	100.0	296.5

TABLE 5D: Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Own Expenditure)—cont.

Category of Performer	1985 Expenditure (Per Cent)									
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other
Q7. What proportions of the research manpower in 6(a) above were employed:										
(a) Permanently (%)	94.8	100.0	100.0	97.9	100.0	65.3	17.2	87.0	89.9	82.4
(b) On fixed term contracts (%)	5.2	0.0	0.0	2.1	0.0	34.7	82.8	13.0	10.1	17.6
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in systematic biology?										
(a) No. Systematists (Man Years)	308.0	1.7	0.0	92.5	0.0	201.6	18.0	87.0	35.4	54.0
(b) No. Involved in Teaching as % of (a)	1.4	1.7	0.0	20.5	0.0	67.1	77.8	3.2	12.7	56.6
(c) No. Supervising Research Students as % of (a)	5.6	0.0	0.0	29.2	0.0	41.4	44.4	26.0	8.5	0.0
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?										
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	12.6	11.2	0.0	0.0	0.0
Q10. How many postgraduate research students were studying systematic biology in your organisation?										
No. PG research students	32.0	1.0	0.0	12.0	1.0	170.6	7.0	29.0	4.0	1.0
Q11. What was the age distribution of your staff teaching systematic biology?										
(a) 35 and under	25.0	0.0	0.0	20.0	0.0	12.9	9.1	37.5	12.5	17.2
(b) 36-45	37.5	100.0	0.0	60.0	0.0	36.2	72.7	43.8	50.0	24.1
(c) 46-55	37.5	0.0	0.0	20.0	0.0	31.8	18.2	18.8	37.5	34.5
(d) 56-65	0.0	0.0	0.0	0.0	100.0	18.2	0.0	0.0	0.0	24.1
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Number
257.614.9
37.7
30.7
16.1
0.7

ANNEX 6 - DATA FOR 1990

TABLE 6A/B: Expenditure on Systematic Biology (£'000 - 1990 prices)

Category of Performer	1990 Expenditure (£'000 - 1990 Prices)										Total (£'000)	%
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other		
Q1. What was your total expenditure on systematic biology?												
Total Expenditure (£'000)	10065.0	200.8	235.2	4925.0	224.0	4164.7	131.5	3970.5	2944.0	3743.5	30604.2	
Q2. What proportions of this total were devoted to:												
(a) Research (£'000)	4347.0	15.1	36.5	2429.7	11.0	3099.6	81.9	3586.8	1562.1	1327.7	16497.2	53.9
(b) Curation (£'000)	3257.9	113.9	123.0	1935.0	33.1	658.5	11.0	215.1	686.0	967.6	8000.9	26.1
(c) Information Services (£'000)	1824.4	42.1	54.3	560.4	10.2	106.2	18.0	168.7	554.3	409.8	3748.4	12.2
(d) Other Activities (£'000)	635.6	29.7	21.4	0.0	169.7	300.4	20.7	0.0	141.7	1038.4	2357.6	7.7
	10065.0	200.8	235.2	4925.0	224.0	4164.7	131.5	3970.5	2944.0	3743.5	30604.2	100.0
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:												
(a) Salaries (£'000)	3703.4	12.0	29.0	1933.1	11.0	2355.4	46.2	2350.0	725.3	894.1	12059.5	73.1
(b) Equipment (£'000)	362.0	1.0	1.8	110.9	0.0	330.1	6.8	190.8	367.2	109.5	1480.2	9.0
(c) General Overheads (£'000)	31.3	2.1	5.4	314.2	0.0	341.8	23.7	989.9	448.3	312.4	2468.9	15.0
(d) Other Activities (£'000)	250.2	0.0	0.3	71.5	0.0	72.4	5.2	56.1	21.2	11.7	488.6	3.0
	4347.0	15.1	36.5	2429.7	11.0	3099.6	81.9	3586.8	1562.1	1327.7	16497.2	100.0
Q4. What were the main sources of funding for your research in systematic biology?												
(a) Core Funding (£'000)	3711.7	13.8	36.2	2246.3	11.0	1608.9	10.2	1425.7	1317.6	0.0	10381.3	62.9
(b) Research Councils (£'000)	164.4	0.0	0.0	8.1	0.0	660.9	28.6	835.6	0.0	316.8	2014.3	12.2
(c) Government Departments (£'000)	124.7	0.9	0.0	63.7	0.0	327.5	21.6	926.5	26.7	308.4	1799.9	10.9
(d) Commercial organisations (£'000)	160.7	0.0	0.0	77.9	0.0	180.9	3.6	343.0	84.7	23.3	874.1	5.3
(e) Self-generated income (£'000)	71.0	0.0	0.3	4.0	0.0	24.9	2.5	56.0	87.6	470.1	716.4	4.3
(f) Other (£'000)	114.5	0.4	0.0	29.7	0.0	296.5	15.4	0.0	45.6	209.2	711.1	4.3
	4347.0	15.1	36.5	2429.7	11.0	3099.6	81.9	3586.8	1562.1	1327.7	16497.2	100.0
Q5. What was your total manpower engaged in systematic biology?												
Total manpower (Man Years)	354.6	11.1	6.5	192.5	2.9	157.7	9.9	126.5	49.0	185.0	1095.6	MnYrs
Q6. What proportions of this manpower were devoted to:												
(a) Research	112.1	0.8	0.8	87.4	0.6	119.9	7.0	105.9	19.7	60.0	514.1	46.9
(b) Curation	141.3	6.3	4.5	85.3	1.8	27.3	1.0	14.8	10.5	30.8	323.5	29.5
(c) Information Services	63.1	3.0	0.8	19.8	0.5	5.2	1.3	5.9	9.6	22.2	131.3	12.0
(d) Other Activities	38.1	1.0	0.5	0.0	0.0	5.2	0.7	0.0	9.2	72.0	126.8	11.6
	354.6	11.1	6.5	192.5	2.9	157.7	9.9	126.5	49.0	185.0	1095.6	100.0

1990 Expenditure (Per Cent)

Category of Performer	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Insitns	Govt Depts	Other	Sum (%)	1990 Expenditure (Per Cent)
Q1. What was your total expenditure on systematic biology? Total Expenditure (%)	32.9	0.7	0.8	16.1	0.7	13.6	0.4	13.0	9.6	12.2	100.0	30604.2
Q2. What proportions of this total were devoted to:												
(a) Research (%)	26.3	0.1	0.2	14.7	0.1	18.8	0.5	21.7	9.5	8.0	100.0	16497.2
(b) Curation (%)	40.7	1.4	1.5	24.2	0.4	8.2	0.1	2.7	8.6	12.1	100.0	8000.9
(c) Information Services (%)	48.7	1.1	1.4	15.0	0.3	2.8	0.5	4.5	14.8	10.9	100.0	3748.4
(d) Other Activities (%)	27.0	1.3	0.9	0.0	7.2	12.7	0.9	0.0	6.0	44.0	100.0	2357.6
	32.9	0.7	0.8	16.1	0.7	13.6	0.4	13.0	9.6	12.2	100.0	30604.2
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:												
(a) Salaries (%)	30.7	0.1	0.2	16.0	0.1	19.5	0.4	19.5	6.0	7.4	100.0	12059.5
(b) Equipment (%)	24.5	0.1	0.1	7.5	0.0	22.3	0.5	12.9	24.8	7.4	100.0	1480.2
(c) General Overheads (%)	1.3	0.1	0.2	12.7	0.0	13.8	1.0	40.1	18.2	12.7	100.0	2468.9
(d) Other Activities (%)	51.2	0.0	0.1	14.6	0.0	14.8	1.1	11.5	4.3	2.4	100.0	488.6
	26.3	0.1	0.2	14.7	0.1	18.8	0.5	21.7	9.5	8.0	100.0	16497.2
Q4. What were the main sources of funding for your research in systematic biology?												
(a) Core Funding (%)	35.8	0.1	0.3	21.6	0.1	15.5	0.1	13.7	12.7	0.0	100.0	10381.3
(b) Research Councils (%)	8.2	0.0	0.0	0.4	0.0	32.8	1.4	41.5	0.0	15.7	100.0	2014.3
(c) Government Departments (%)	6.9	0.0	0.0	3.5	0.0	18.2	1.2	51.5	1.5	17.1	100.0	1799.9
(d) Commercial organisations (%)	18.4	0.0	0.0	8.9	0.0	20.7	0.4	39.2	9.7	2.7	100.0	874.1
(e) Self-generated income (%)	9.9	0.0	0.0	0.6	0.0	3.5	0.3	7.8	12.2	65.6	100.0	716.4
(f) Other (%)	16.1	0.1	0.0	4.2	0.0	41.7	2.2	0.0	6.4	29.4	100.0	711.1
	26.3	0.1	0.2	14.7	0.1	18.8	0.5	21.7	9.5	8.0	100.0	16497.2
Q5. What was your total manpower engaged in systematic biology? Total manpower (%)	32.4	1.0	0.6	17.6	0.3	14.4	0.9	11.5	4.5	16.9	100.0	MnYrs 1095.6
Q6. What proportions of this manpower were devoted to:												
(a) Research (%)	21.8	0.1	0.1	17.0	0.1	23.3	1.4	20.6	3.8	11.7	100.0	514.1
(b) Curation (%)	43.7	2.0	1.4	26.4	0.6	8.4	0.3	4.6	3.2	9.5	100.0	323.5
(c) Information Services (%)	48.1	2.3	0.6	15.1	0.4	4.0	1.0	4.5	7.3	16.9	100.0	131.3
(d) Other Activities (%)	30.1	0.8	0.4	0.0	0.0	4.1	0.6	0.0	7.2	56.8	100.0	126.8
	32.4	1.0	0.6	17.6	0.3	14.4	0.9	11.5	4.5	16.9	100.0	1095.6

TABLE 6C: Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Total Expenditure)—cont.

Category of Performer	1990 Expenditure (Per Cent)										Sum (%)	Total (£'000)	
	National Museums	Regional Museums	University Museums	National Gardens	Other Gardens	University Depts	Polys & Other HE	RC Instns	Govt Depts	Other			
Q7. What proportions of the research manpower in 6(a) above were employed:													
(a) Permanently (%)	20.6	0.2	0.2	21.0	0.2	19.8	0.3	18.9	4.2	14.6	100.0	358.3	
(b) On fixed term contracts (%)	24.7	0.0	0.0	7.9	0.0	31.4	3.7	24.5	3.0	4.8	100.0	155.7	
	21.8	0.1	0.1	17.0	0.1	23.3	1.4	20.6	3.8	11.7	100.0	514.1	
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?													
(a) No. Systematists (% of Total Manpower)	36.9	0.5	0.0	14.0	0.0	23.1	2.6	11.0	5.2	6.7	100.0	772.1	
(b) No. Involved in Teaching (% of Systematists)	8.6	0.0	0.0	11.4	0.1	55.8	4.9	1.3	2.2	15.7	100.0	202.4	
(c) No. Supervising Research Students (% of Systematists)	13.9	0.0	0.0	19.8	0.0	43.1	4.2	13.7	4.2	1.2	100.0	166.9	
Q9. What proportion of the time of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?													
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	8.9	8.8	0.0	0.0	0.0	8.9		
Q10. How many postgraduate research students were studying systematic biology in your organisation?													
No. PG research students	12.4	0.3	0.0	6.2	0.3	62.0	4.1	11.4	2.4	0.7	100.0	289.7	
Q11. What was the age distribution of your staff teaching systematic biology?													
(a) 35 and under	5.0	0.0	0.0	2.5	5.0	40.1	0.0	15.0	2.5	29.9	100.0	40.1	
(b) 36-45	3.0	1.0	0.0	1.0	0.0	55.1	6.1	5.5	3.0	25.2	100.0	99.1	
(c) 46-55	5.6	0.0	0.0	4.7	0.0	70.0	8.4	3.7	2.8	4.7	100.0	106.7	
(d) 56-65	1.6	0.0	0.0	1.6	0.0	73.3	1.6	1.6	3.1	17.3	100.0	63.6	
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	1.0	
	3.9	0.3	0.0	2.6	0.6	62.2	5.2	5.3	2.9	17.1	100.0	310.5	

TABLE 6D: Expenditure on Systematic Biology (Former Expenditure as a Per Cent of Own Expenditure)

[illegible]

ANNEX 7 - SUMMARY OF DATA FOR 1980, 1985 AND 1990

TABLE 7.1: *Expenditure on Systematic Biology (£'000 - 1990 prices)*

Category of Performer	1980, 1985 & 1990 Expenditure (£'000 - 1990 Prices)									
	Museums 1980 1985 1990	Gardens 1980 1985 1990	Higher Education 1980 1985 1990	RC Inst. 1980 1985 1990	Govt Labs/Depts 1980 1985 1990	Other Organs 1980 1985 1990	Total			
							1980	1985	1990	
Q1. What was your total expenditure on systematic biology?										
Total Expenditure (£'000)	10.77 10.55 10.50	4.20 3.95 5.15	4.78 4.28 4.30	4.82 4.25 3.97	2.66 2.72 2.94	2.66 2.89 3.74	29.90	28.64	30.60	
Q2. What proportions of this total were devoted to:										
(a) Research (£'000)	5.89 5.60 4.40	1.92 1.78 2.44	3.65 3.13 3.18	4.18 3.74 3.59	1.21 1.16 1.56	0.67 0.91 1.33	17.53	16.32	16.50	
(b) Curation (£'000)	2.72 2.70 3.49	1.44 1.38 1.97	0.72 0.73 0.67	0.28 0.24 0.22	0.77 0.78 0.69	0.58 0.63 0.97	6.50	6.45	8.00	
(c) Information Services (£'000)	1.62 1.70 1.92	0.64 0.59 0.57	0.12 0.13 0.12	0.36 0.27 0.17	0.49 0.53 0.55	0.31 0.32 0.41	3.53	3.53	3.75	
(d) Other Activities (£'000)	0.55 0.55 0.69	0.19 0.20 0.17	0.29 0.30 0.32	0.00 0.00 0.00	0.20 0.25 0.14	1.10 1.04 1.04	2.34	2.34	2.36	
	10.77 10.55 10.50	4.20 3.95 5.15	4.78 4.28 4.30	4.82 4.25 3.97	2.66 2.72 2.94	2.66 2.89 3.74	29.90	28.64	30.60	
Q3. What proportions of your total expenditure on systematic biology research in 2(1) above were spent on:										
(a) Salaries (£'000)	5.11 4.94 3.74	1.47 1.43 1.94	2.92 2.52 2.40	2.52 2.32 2.35	0.64 0.59 0.73	0.46 0.59 0.89	13.11	12.41	12.06	
(b) Equipment (£'000)	0.25 0.29 0.36	0.17 0.11 0.11	0.21 0.21 0.34	0.38 0.29 0.19	0.29 0.29 0.37	0.04 0.05 0.11	1.34	1.23	1.48	
(c) General Overheads (£'000)	0.06 0.06 0.04	0.17 0.16 0.31	0.46 0.33 0.37	1.24 1.09 0.99	0.26 0.27 0.45	0.17 0.26 0.31	2.36	2.17	2.47	
(d) Other Activities (£'000)	0.47 0.31 0.25	0.12 0.09 0.07	0.06 0.06 0.08	0.04 0.04 0.06	0.02 0.01 0.02	0.00 0.01 0.01	0.72	0.52	0.49	
	5.89 5.60 4.40	1.92 1.78 2.44	3.65 3.13 3.18	4.18 3.74 3.59	1.21 1.16 1.56	0.67 0.91 1.33	17.53	16.32	16.50	
Q4. What are the main sources of funding for your research in systematic biology?										
(a) Core Funding (£'000)	4.78 5.44 3.76	1.89 1.73 2.26	2.11 1.69 1.62	1.68 1.49 1.43	1.06 0.86 1.32	0.00 0.00 0.00	11.47	11.21	10.38	
(b) Research Councils (£'000)	0.55 0.06 0.16	0.00 0.00 0.01	0.63 0.69 0.69	2.05 1.39 0.84	0.00 0.00 0.00	0.08 0.13 0.32	3.32	2.28	2.01	
(c) Government Departments (£'000)	0.01 0.06 0.13	0.01 0.02 0.06	0.63 0.39 0.35	0.31 0.71 0.93	0.00 0.21 0.03	0.24 0.32 0.31	1.19	1.71	1.80	
(d) Commercial Organisations (£'000)	0.28 0.02 0.16	0.01 0.01 0.08	0.10 0.12 0.18	0.00 0.06 0.34	0.00 0.00 0.08	0.01 0.00 0.02	0.39	0.21	0.87	
(e) Self-generated Incomes (£'000)	0.17 0.02 0.07	0.00 0.00 0.00	0.02 0.04 0.03	0.19 0.08 0.06	0.13 0.04 0.09	0.18 0.24 0.47	0.69	0.42	0.72	
(f) Other (£'000)	0.12 0.01 0.11	0.02 0.02 0.03	0.16 0.20 0.31	0.00 0.00 0.00	0.02 0.04 0.05	0.16 0.23 0.21	0.47	0.49	0.71	
	5.89 5.60 4.40	1.92 1.78 2.44	3.65 3.13 3.18	4.18 3.74 3.59	1.21 1.16 1.56	0.67 0.91 1.33	17.53	16.32	16.50	
Q5. What was your total manpower engaged in systematic biology?										
Total manpower (Man Years)	405.9 400.1 372.2	180.1 176.1 195.4	186.2 170.9 167.6	132.2 126.9 126.5	45.3 44.3 49.0	175.1 182.8 185.0	1124.8	1101.1	1095.6	MnYrs
Q6. What proportions of this manpower were devoted to:										
(a) Research (Man Years)	152.7 158.1 113.6	78.0 75.8 88.0	138.6 128.0 126.9	112.1 110.1 105.9	15.9 13.0 19.7	54.4 59.0 60.0	551.5	546.7	514.1	
(b) Curation (Man Years)	155.8 147.3 152.1	79.3 75.9 87.1	32.6 32.4 28.2	13.0 9.4 14.8	11.2 12.5 10.5	26.7 28.8 30.8	318.7	306.3	323.5	
(c) Information Services Years)	62.6 61.9 66.8	22.8 21.8 20.3	10.6 5.2 6.5	7.1 7.5 5.9	9.1 8.3 9.6	19.5 19.0 22.2	131.8	123.6	131.3	
(d) Other Activities (Man Years)	34.7 32.7 39.7	0.0 0.0 0.0	4.5 5.3 5.9	0.0 0.0 0.0	9.1 10.4 9.2	74.5 76.1 72.0	122.8	124.6	126.8	
	405.9 400.1 372.2	180.1 176.1 195.4	186.2 170.9 167.6	132.2 126.9 126.5	45.3 44.3 49.0	175.1 182.8 185.0	1124.8	1101.1	1095.6	

TABLE 7.1: Expenditure on Systematic Biology (£'000 - 1990 prices)—cont.

Category of Performer	Museums		Gardens		Higher Education		RC Inst.		Govt Labs/Depts		Other Orgns		Total								
	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990						
Q7. What proportions of the research manpower in 6(a) above were employed:																					
(a) Permanently	151.3	150.0	75.1	76.8	76.8	75.7	103.2	81.3	72.2	103.9	95.8	67.7	15.9	11.7	15.1	48.7	48.6	52.5	499.8	464.3	358.3
(b) On fixed term contracts	1.45	8.1	38.4	1.2	1.7	12.3	35.3	46.7	54.7	8.2	14.3	38.1	0.0	1.3	4.7	5.7	10.4	7.5	51.8	82.4	155.7
	152.7	158.1	113.6	78.0	78.5	88.0	138.6	128.0	126.9	112.1	110.1	105.9	15.9	13.0	19.7	54.4	59.0	60.0	551.5	546.7	514.1
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?																					
(a) No Systematists (Man Years)	312.9	309.7	288.6	92.5	92.5	108.0	244.7	219.6	198.5	85.5	87.0	85.3	35.2	35.4	40.4	52.0	54.0	51.4	822.8	798.1	772.1
(b) No. Involved in Teaching (Man Years)	3.2	4.4	17.5	18.1	19.1	23.1	171.7	149.2	122.9	3.1	2.8	2.6	4.5	4.5	4.5	14.4	30.6	31.8	215.0	210.5	202.4
(c) No. Supervising Research Students (Man Years)	12.1	17.2	23.2	27.0	27.0	33.0	109.9	91.4	78.9	16.5	22.6	22.8	3.0	3.0	7.0	0.0	0.0	2.0	168.5	161.2	166.9
Q9. What proportions of the time of your of your undergraduate students reading for degrees in Biological Science was spent in courses which deal with Systematic Biology?																					
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	0.0	17.1	12.4	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	12.4	8.9
Q10. How many postgraduate research students were studying systematic biology in your organisation?																					
No. PG research students	16.0	33.0	37.0	12.0	13.0	19.0	202.0	177.6	191.7	20.0	29.0	33.0	4.0	4.0	7.0	1.0	5.0	12.0	255.0	257.6	289.7
Q11. What was the age distribution of your staff teaching systematic biology?																					
(a) 35 and under	0.0	2.0	2.0	0.0	1.0	3.0	63.0	29.1	16.1	8.0	6.0	6.0	3.0	1.0	1.0	0.0	1.0	1.0	74.0	44.1	40.1
(b) 36-45	2.0	4.0	4.0	4.0	3.0	1.0	87.9	86.7	60.6	4.0	7.0	3.0	4.0	4.0	5.5	0.0	7.0	25.0	10.9	111.7	99.1
(c) 46-55	1.0	3.0	6.0	1.0	1.0	5.0	77.5	71.1	83.7	7.0	3.0	4.0	1.0	3.0	3.0	0.0	10.0	5.0	87.5	91.1	106.7
(d) 56-65	0.0	0.0	1.0	0.0	1.0	1.0	39.5	39.6	47.6	0.0	0.0	1.0	0.0	0.0	2.0	0.0	7.0	11.0	35.9	47.6	63.3
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0	1.0
	3.0	9.0	13.0	5.0	6.0	10.0	268.3	228.5	209.0	19.0	16.0	16.5	8.0	8.0	9.0	0.0	29.0	53.0	303.3	296.5	310.5

TABLE 7.2: Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Total Expenditure for the Year in Question) 1980, 1985 & 1990 Expenditure (Per Cent)

Category of Performer	Museums			Gardens			Higher Education			RC Inst.			Govt Labs/Depts			Other Orgns			Total		
	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990
Q7. What proportion of the research manpower in 6(a) above were employed:																					
(a) Permanently (%)	30.3	32.3	21.0	15.4	16.5	21.1	20.7	17.5	20.1	20.8	20.6	18.9	3.2	2.5	4.2	9.7	10.5	14.6	499.8	464.3	358.3
(b) On fixed term contracts (%)	2.6	9.8	24.7	2.3	2.0	7.9	68.3	56.7	35.1	15.9	17.3	24.5	0.0	1.6	3.0	11.0	12.6	4.8	51.8	82.4	155.7
	27.7	28.9	22.1	14.1	14.4	17.1	25.1	23.4	24.7	20.3	20.1	20.6	2.9	2.4	3.8	9.9	10.8	11.7	551.5	546.7	514.1
Q8. How many of your staff were systematists and how many were actively engaged in teaching courses or supervising higher degrees in Systematic Biology?																					
(a) No Systematists (% Total Manpower)	38.0	38.8	37.4	11.2	11.6	14.0	29.7	27.5	25.7	10.4	10.9	11.0	4.3	4.4	5.2	6.3	6.8	6.7	103.1	103.4	772.1
(b) No. Involved in Teaching (% Systematists)	1.5	2.1	8.6	8.4	9.1	11.4	79.9	70.9	60.7	1.4	1.3	1.3	2.1	2.1	2.2	6.7	14.5	15.7	215.0	210.5	202.4
(c) No. Supervising Research Students (% Systematists)	7.2	10.4	13.9	16.0	16.8	19.8	65.2	56.7	47.3	9.8	14.0	13.7	1.8	1.9	4.2	0.0	0.0	0.2	168.5	161.2	166.9
Q9. What proportion of the time of your undergraduate students reading for degrees in biological Science was spent in courses which deal with Systematic Biology?																					
% time devoted to systematics	0.0	0.0	0.0	0.0	0.0	0.0	17.1	12.4	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	12.4	8.9
Q10. How many postgraduate research students were studying systematic biology in your organisation?																					
No. PG research students	6.3	12.8	12.8	4.7	5.0	6.6	79.2	68.9	66.2	7.8	11.3	11.4	1.6	1.6	2.4	0.4	0.4	0.7	255.0	257.6	289.7
Q11. What was the age distribution of your staff teaching systematic biology?																					
(a) 35 and under	0.0	4.5	50.0	0.0	2.3	7.5	85.1	66.0	40.1	10.8	13.6	15.0	4.1	2.3	2.5	0.0	11.3	29.9	74.0	44.1	40.1
(b) 36-45	2.0	3.6	4.0	3.0	2.7	1.0	86.3	77.6	61.2	3.9	6.3	5.5	3.9	3.6	3.0	0.0	6.3	25.2	101.9	111.7	99.1
(c) 46-55	1.1	3.3	5.6	1.1	1.1	4.7	88.6	78.0	78.4	8.0	3.3	3.7	1.1	3.3	2.8	0.0	11.0	4.7	87.5	91.1	106.7
(d) 56-65	0.0	0.0	1.6	0.0	2.1	1.6	100.0	83.2	74.8	0.0	0.0	1.6	0.0	0.0	3.1	0.0	14.7	17.3	35.9	47.6	63.6
(e) 65 and over	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0	1.0
	1.0	3.0	4.2	1.6	2.0	3.2	88.5	77.1	67.3	6.3	5.4	5.3	2.6	2.7	2.9	0.0	9.8	17.1	303.3	296.5	310.5

TABLE 7.3: Expenditure on Systematic Biology (Performer Expenditure as a Per Cent of Own Expenditure)

Category of Performer	1980, 1985 & 1990 Expenditure (Per Cent)									
	Museums 1980 1985 1990	Gardens 1980 1985 1990	Higher Education 1980 1985 1990	RC Inst. 1980 1985 1990	Govt Labs/Depts 1980 1985 1990	Other Orgns 1980 1985 1990	Total (1990, £'000)			
Q1. What was your total expenditure on systematic biology?										
Total Expenditure (£'000)	10.77 10.55 10.50	4.20 3.95 5.15	4.78 4.28 3.97	4.82 4.25 3.97	2.66 2.72 2.94	2.66 2.89 3.74		29.90	28.64	30.60
Q2. What proportions of this total were devoted to:										
(a) Research (%)	54.7 53.1 41.9	45.8 45.2 47.4	76.3 73.0 74.1	86.7 87.9 90.3	45.5 42.8 53.1	25.2 31.5 35.5		58.6	57.0	53.9
(b) Curation (%)	25.2 25.6 33.3	34.4 35.0 38.2	15.0 17.0 15.6	5.8 5.8 5.4	28.7 28.5 23.3	21.8 21.6 25.8		21.7	22.5	26.1
(c) Information Services (%)	15.0 16.1 18.3	15.2 14.9 11.1	2.6 3.0 2.9	7.5 6.3 4.2	18.2 19.5 18.8	11.6 10.9 10.9		11.8	12.3	12.2
(d) Other Activities (%)	5.1 5.2 6.5	4.6 4.9 3.3	6.2 7.1 7.5	0.0 0.0 0.0	7.5 9.2 4.8	41.5 36.0 27.7		7.8	8.2	7.7
	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0		100.0	100.0	100.0
Q3. What proportions of your total expenditure on systematic biology research in 2(a) above were spent on:										
(a) Salaries (%)	86.8 88.2 85.1	76.1 80.3 79.7	79.9 80.7 75.5	60.2 62.1 65.5	52.8 51.1 46.4	68.2 65.1 67.3		74.8	76.0	73.1
(b) Equipment (%)	4.3 5.2 8.3	8.7 6.0 4.5	5.8 6.8 10.6	9.0 7.6 5.3	24.0 24.6 23.5	5.5 5.3 8.3		7.6	7.5	9.0
(c) General Overheads (%)	1.0 1.1 0.9	8.7 8.9 12.9	12.5 10.5 11.5	29.7 29.1 27.6	21.6 23.5 28.7	25.7 28.7 23.5		13.5	13.3	15.0
(d) Other Activities (%)	8.0 5.5 5.7	6.4 4.8 2.9	1.7 2.0 2.4	1.0 1.2 1.6	1.6 0.8 1.4	0.6 0.9 0.9		4.1	3.2	3.0
	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0		100.0	100.0	100.0
Q4. What were the main sources of funding for your research in systematic biology?										
(a) Core Funding (%)	81.1 97.1 85.5	98.1 97.1 92.5	57.7 54.1 50.9	39.1 39.8 39.7	87.7 74.0 84.3	0.0 0.0 0.0		65.4	68.7	62.9
(b) Research Councils (%)	9.4 1.1 3.7	0.2 0.2 0.3	17.2 22.0 21.7	49.0 37.3 23.3	0.0 0.0 0.0	12.7 14.1 23.9		18.9	13.9	12.2
(c) Government Departments (%)	0.1 1.0 2.9	0.3 1.2 2.6	17.3 12.6 11.0	7.4 19.1 25.8	0.0 18.4 1.7	34.4 34.6 23.2		6.8	10.5	10.9
(d) Commercial Organisations (%)	4.7 0.3 3.7	0.5 0.5 3.2	2.8 3.8 5.8	0.0 1.7 9.6	0.0 0.0 5.4	0.9 0.4 1.8		2.2	1.3	5.3
(e) Self-generated Incomes (%)	2.8 0.4 1.6	0.0 0.0 0.2	0.6 1.3 0.9	4.5 2.2 1.6	11.0 3.8 5.6	26.7 25.8 35.4		3.9	2.6	4.3
(f) Other (%)	2.0 0.1 2.6	0.9 1.0 1.2	4.3 6.3 9.8	0.0 0.0 0.0	1.3 3.7 2.9	24.2 25.1 15.8		2.7	3.0	4.3
	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0		100.0	100.0	100.0
Q5. What was your total manpower engaged in systematic biology?										
Total manpower (Man Years)	405.9 400.1 372.2	180.1 176.1 195.4	186.2 170.9 167.6	132.2 126.9 126.5	45.3 44.3 49.0	175.1 182.8 185.0		1124.8	1101.1	1095.6
Q6. What proportions of this manpower were devoted to:										
(a) Research (%)	37.6 39.5 30.5	43.3 44.6 45.0	74.4 74.9 75.7	84.8 86.7 83.7	35.0 29.5 40.3	31.1 32.3 32.4		49.0	49.6	46.9
(b) Curation (%)	38.4 36.8 40.9	44.0 43.1 44.6	17.5 18.9 16.8	9.8 7.4 11.7	24.7 28.3 21.4	15.3 15.7 16.6		28.3	27.8	29.5
(c) Information Services (%)	15.4 15.5 18.0	12.7 12.4 10.4	5.7 3.0 3.9	5.4 5.9 4.6	20.1 18.7 19.6	11.1 10.4 12.0		11.7	11.2	12.0
(d) Other Activities (%)	8.6 8.2 10.7	0.0 0.0 0.0	2.4 3.1 3.5	0.0 0.0 0.0	20.1 23.6 18.7	42.5 41.6 38.9		10.9	11.3	11.6
	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0		100.0	100.0	100.0

MinYrs

APPENDIX 3

List of Witnesses

The following witnesses gave evidence. Those marked * gave oral evidence.

- Advisory Board for the Research Councils
- *Agriculture and Food Research Council
- Professor R M Anderson FRS
- Professor C Arne
- Association of the British Pharmaceutical Industry
- Professor dr P Baas
- *Henry S Barlow
- Professor R J H Beverton FRS
- *Dr F A Bisby
- Bolton Museum and Art Gallery, Biology Curators Group
- W R P Bourne
- Professor A D Bradshaw FRS
- *Dr P Bridgewater
- British Ecological Society
- British Ornithologists' Union
- Professor A T Bull
- Dr J Burley
- Sir John Burnett
- *CAB International
- Professor A J Cain
- Chelsea Physic Garden
- Professor B C Clarke FRS
- Commission of the European Communities
- Committee of Directors of Polytechnics
- Committee of Vice-Chancellors and Principals
- Conchological Society of GB and Ireland
- Coordinating Commission for Biological Recording
- Professor R G Davies
- *Department of Education and Science
- *Department of the Environment
- Dr R H L Disney
- Dr Z Erzinclioglu
- European Garden Flora Project Editorial Committee
- FENSCORE
- Fish Conservation Centre
- Flora Europaea Editorial Committee
- Professor G E Fogg FRS
- Forestry Commission
- Avril Fox
- German Research Council (DFG)
- *Mr E F Greenwood
- Dr P H Greenwood DSc FRS
- Professor dr Werner Greuter
- Sir Wm Halcrow & Partners Ltd
- Hallé, Professor F
- Professor Sir Richard Harrison MD FRS
- Professor J R Haynes
- Professor G M Hewitt
- *Professor V H Heywood
- Home Office
- C V Horie
- Dr D S Ingram
- Institute of Biology
- Institution of Professionals, Managers and Specialists
- International Society of Hymenopterists
- International Union of Biological Sciences
- Joint Nature Conservation Committee

Dr S L Jury
Professor R W J Keay
Barbara Kirsop
Lancashire Polytechnic
*Professor J H Lawton FRS
Leicester Polytechnic
*Linnean Society of London
Liverpool Polytechnic
Malacological Society of London
*Manchester Museum
John Marsden, Secretary, The Linnean Society of London
*Professor R M May FRS
Professor E Mayr FFRS
Medical Research Council
*Ministry of Agriculture, Fisheries and Food
National Council for the Conservation of Plants and Gardens
National Federation for Biological Recording
National Institute of Agricultural Botany
*National Museum and Galleries on Merseyside
*National Museums of Scotland
*National Museum of Wales—Amgueddfa Genedlaethol Cymru
National Rivers Authority
*Natural Environment Research Council
*Natural History Museum
Nature Magazine
*Office of Arts and Libraries
*Overseas Development Administration
Paisley College, Department of Biology
Palaeontographical Society
Palaeontological Association
Dr A L Panchen
*Dr C Patterson
Professor T H Pennington
Polychaete Society
Porcupine
Portsmouth Polytechnic
Public Health Laboratory Service
Rare Breeds Survival Trust Ltd
Dr Peter Raven (Missouri Botanical Garden)
Dr B Richardson, Australian National Parks and Wildlife Service
*Professor W D L Ride, Australian National Parks and Wildlife Service
Sir Ralph Riley FRS
Professor F E Round
*Royal Botanic Gardens, Kew
Royal Entomological Society of London
Royal Horticultural Society
*Royal Society
Royal Society of Tropical Medicine and Hygiene
Science and Engineering Research Council
*Scottish Office
Scottish Marine Biological Association
Dr J B Searle
SmithKline Beecham
Smithsonian Institution
Smithsonian Tropical Research Institute
Society for General Microbiology
*Professor C Stace
*Systematics Association
Thames Polytechnic
Unilever plc
University of Aberdeen, Principal and Vice-Chancellor

University of Cambridge
 University of Dublin Trinity College
 University of East Anglia
 University of Edinburgh (and Sir David Smith FRS FRSE)
 University of Exeter
 University of Leicester (Professors Smith and Stace)
 University of Newcastle upon Tyne
 University of Newcastle upon Tyne, Hancock Museum
 University of Oxford, The University Museum
 University of Sheffield
 WRC plc
 Dr S M Walters
 Welsh Office
 Professor H B Whittington FRS
 Dr C C Wilcock FLS
 Wolverhampton Polytechnic
 World Conservation Monitoring Centre
 World Resources Institute
 Zoological Society of London

APPENDIX 4

Invitation to submit written evidence (United Kingdom)

The Select Committee on Science and Technology have appointed a Sub-Committee, under the chairmanship of Lord Dainton, with terms of reference "to consider systematic biology research in the United Kingdom".

The Sub-Committee invite you to submit written evidence to them on any matters relevant to their terms of reference and in particular on the following issues:

- (i) What is the utility of systematic biology research?
- (ii) Does the need to specify particular organisms in connection with eg intellectual property rights, regulatory provisions etc, impinge upon your work?
- (iii) Is the level of United Kingdom research appropriate. If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?
- (iv) Is United Kingdom research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate, for example importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?
- (v) What is the extent of our need for reference collections including foreign material (type collections, living culture collections, etc) as a base for systematic research? Is provision for their storage and their curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?
- (vi) What new methods are there and how will this affect future United Kingdom research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is United Kingdom research taking cognizance of the full range of new developments in this field?
- (vii) Is the current "institutionalised" base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?
- (viii) If research is to be continued who pays?
 - (i) Should burdens of expense be shared with other countries—that is a UN programme? Can ESF help to rationalise activities?
 - (ii) Within United Kingdom, how much more should Government pay for and how best can budgets be protected?
 - (iii) What role can industry play?
- (ix) Is teaching adequate?
- (x) What can we learn from abroad, especially the USA?

It may be, of course, that not all of these issues will be of concern to you and that you will wish to concentrate on only those areas in which you have experience.

Evidence should be submitted to the Clerk of Sub-Committee II (Systematic Biology Research), Select Committee on Science and Technology, House of Lords, London SW1A 0PW. Evidence must be clearly printed and take the form of an original copy. Pre-published documents and documents prepared for other purposes will not normally be received as evidence. It would assist the Committee if evidence were prefaced with an executive summary or precis.

The Committee will decide at a latter date whom to invite to give additional oral evidence.

If you have any queries please contact me on 071-219 6075 (telephone), 071-219 6715 or 071 219 4931 (fax).

R H Walters

CLERK OF SUB-COMMITTEE II

Invitation to submit written evidence (Foreign)

The Select Committee on Science and Technology have appointed a Sub-Committee, under the chairmanship of Lord Dainton, with terms of reference "to consider systematic biology research in the United Kingdom".

The Sub-Committee would be very grateful for your views on any matters relevant to their terms of reference. They would particularly value any comments that you might care to offer from your perspective as a worker in the field of systematics from outside Britain, who has had experience of the workings of science in this country. They are particularly interested in the following issues:

- (i) In your experience, is the level of United Kingdom research appropriate? If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?
- (ii) So far as you can judge, is United Kingdom research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate eg importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality resources available?
- (iii) What is the international need for British reference collections including foreign material (type collections, living cultures collections, etc), as a base for systematic research? Is provision for their storage and their curation adequate? Does the United Kingdom have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings? How far do you judge that it is fulfilling these obligations, with appropriate research and publications, within those aspects of biological systematics with which you have experience?
- (iv) Do you judge that systematic research in Britain is maintaining its relative position in world science, back-sliding, or improving its status on an international scale, in terms of:
 - (a) the application of new methodology?
 - (b) the level of funding available for research?
 - (c) the priority given to systematics in comparison with other areas of biology, and other science generally?
 - (d) the level and quality of training available to students in our universities and the graduate and undergraduate level?
 - (e) the encouragement/opportunities given to young people to enter research careers in this field?
- (v) Have you had research or other contacts with the Natural History Museum (one-time British Museum of Natural History) and are you aware of the changes already taking place in their research structure and priorities? If so, do you believe that they will enhance the level of research and service given to the world scientific community by that body?
- (vi) Are there aspects of systematic research and training, and the way in which they are funded in your own country, from which you think we could learn useful lessons?

The Committee would welcome any response which you might feel able to make. It may be, of course, that not all of these issues will be of concern to you and that you will wish to concentrate on only those areas in which you have experience.

Your evidence should be sent to me, the Clerk of Sub-Committee II (Systematic Biology Research), Select Committee on Science and Technology, House of Lords, London SW1A 0PW.

R H Walters

CLERK OF SUB-COMMITTEE II

APPENDIX 5

Visit to Washington DC: a note by the Chairman

The Earl of Selborne and I, accompanied by Professor Chaloner and the Clerk, visited Washington DC and undertook a programme of meetings on 2, 3 and 4 October. A list of the organisations visited is appended. The visit was very fruitful. It was clear that the state of systematic biology research in the United States was in many respects similar to that in the United Kingdom, and witnesses endorsed much of the evidence which we had already received in a United Kingdom context. There were, however, some significant differences, particularly in funding mechanisms, and a number of transferrable lessons suggested themselves. For the convenience of the Committee, there follows below a summary of the more important points which were made to us, arranged thematically.

Funding

1. The chief agency for funding systematic biology research was the National Science Foundation, which spent \$13.7 million in FY 1990. This represented about 90 per cent of all basic research in systematics. NSF were able to fund some 30 per cent of the 350 projects put up to them annually. There was a general view at NSF and among other scientists that systematic biology research needed to be a separate and protected "line item" as it was, and indeed it always had been, within the NSF budget. **The question arises whether the United Kingdom should make some kind of separate provision for research council funding of systematic biology research. US witnesses thought that it should.**

2. The NSF also had a Biological Research Resources Program with separate funds, to which institutions could apply for collection improvement grants. About \$5-6 million a year was spent in this way. **There is no United Kingdom equivalent. Should there be?**

3. The relative decline of public funding in State universities in recent years had accelerated the growth of revenue raising research subjects, like molecular biology, at the expense of systematics. The sequence of events had been:

- (a) Funding for state universities had fallen in real value.
- (b) "Expensive biology" (mainly molecular and biochemical) potentially brought big grants, the heavy pro rata overheads of which helped to compensate for this.
- (c) University staff appointments had been influenced by the need to win such grant support, and this had meant that new staff appointments had to be in the big grant-pulling areas.

There appeared to be an analogy with United Kingdom experience here.

4. An NSF task force report "Adapting to the Future" had identified systematic biology research as a target for special support. In the words of the task force, "occasionally it happens that although a given field is important and necessary, the market "fails" ie the number of scientists and faculty dwindles and programs disappear". The task force had bid for an extra \$11 million for biodiversity. This would have doubled the budget available for systematic biology research. We were given the impression that such provision would have been made in the present financial year had the Gram-Rudman-Hollings amendments not bitten in to the budget agreed by Congress.

5. The problems of funding systematic biology research in universities lay not at federal level (NSF) but more at state and local level. While "soft" money had held up reasonably well, infrastructure was very much at risk. The long-term prospects were to that extent poor.

6. As in the United Kingdom, systematists looked principally to federal funding for systematic biology research. A recent grant by the pharmaceutical company MERCK of \$1 million for work on plants by INBio in Costa Rica was considered unusual. Industry as a whole was unlikely to take

much interest in systematic biology research in the near future. **This bears out what United Kingdom witnesses have said.**

7. **There had been a contraction in the number of university based collections, as in the United Kingdom.**

8. We noted that the United States Department of Agriculture had a large rôle in systematics. It ran the Systematic Entomology Laboratory with a budget of \$2.5 million and 26 research scientists. The SEL also ran the Smithsonian entomological collection. It specialised in new world entomology, while leaving old world/Africa to CABI. **Does this represent an informal division of labour which could be taken further in the international specialisation of systematic biology research?**

9. The current interest in biodiversity, and the increase in spending by international agencies which might well follow, should impel governments to ensure that their major institutions can respond on all fronts to the demands and obligations which the international community might place upon them. So far as the United Kingdom was concerned, the NHM and Kew should be provided for in such a way as to enable them to respond to the challenge. Failure to maintain competence across the board was a handicap in meeting unforeseen scientific demands and the movement to preserve biodiversity was at least foreseeable.

Curation and Research

10. It was generally agreed that a well curated collection should ideally have research regularly conducted upon it within the institution that housed it by its "curator". Not all those who are associated with caring for the collection would necessarily have a research function. However, unless in-house research was conducted the collection became moribund, and its intellectual development ceased. Visiting scientists were no substitute for in-house researchers in this regard. **Many United Kingdom witnesses have said the same.**

11. It was possible to have two levels of curators—commissioned and non-commissioned officers—only one of which undertook original research. For such a regime to succeed, it was necessary to provide a strong element of team spirit and to ensure that the NCOs, the technician curators, did not become a dominant professional force. **Does this have bearing on the United Kingdom?**

12. The National Museum and the New York Botanic Garden had recently set up advisory boards to advise on their research programme, and the American Museum had recently appointed more scientists to its governing body. **Are there implications for the NHM and other institutions here?**

13. Scientists were themselves beginning to prioritise their research needs. Exercises by both the Association of Systematics Collections and the Ecologists had recently come to very similar conclusions about priorities in systematic research.

14. US systematists had recently set up a steering committee to consider research trends and priorities in systematics, to be called "Systematics Agenda 2000: integrating biological diversity and societal needs". The NSF had given funding to the Association of Systematics Collections to undertake this work. **Should such an initiative be undertaken in the United Kingdom?**

Co-ordination and organisation

National

15. Formal teaching and research collaboration between the institutions and the universities were valuable. In many cases this had been forced on the subject by the decline of systematics at the universities. It was stressed that such collaboration did not occur naturally and usually came about at the instigation of the universities, who also brought such funding as might be required (though such collaborations did not have to cost anything). Private institutions were better at establishing such links than public institutions. Examples of such collaboration were given by the American Museum and the New York Botanic Garden. Collaboration did not have to be with the nearest university, nor indeed with only one university, eg the American Museum collaborated with 5 universities, including Yale and Cornell.

16. The Association of Systematics Collections was a private association of professional museum systematists. **The question arises whether the United Kingdom should have similar a similar association so as to raise the profile of the membership and to help co-ordinate museums' systematic research activity?**

International

17. Direct United Kingdom/United States links should be established to enable the United Kingdom to take advantage of US plans for a nationwide data recovery programme for systematics collections (the MITRE project based at the Smithsonian). **Should NERC be asked to fund such collaboration?**

18. Most thought that systematic biology research should be considered at international level, but there was wide mistrust of existing inter-governmental institutions. It was suggested that the subject was suitable for inclusion in the agenda of G7 science advisors' meetings.

Training of Systematists

19. It was generally acknowledged that there was a shortage of systematists (both researchers and faculty) in the United States. This had recently been identified by the NSF task force "Adapting to the Future" but no action had as yet been taken to meet the needs identified by that body.

20. University professors of systematics were an ageing population.

21. It was generally agreed that systematic biology had been displaced from university curricula by the expansion of molecular biology and the financial advantages which appointments and grants in that field brought. This reduced the number of universities offering systematics courses. Exceptionally, some small undergraduate school general degrees in wildlife conservation etc had managed to preserve a high element of systematic teaching.

22. It was implied that the decline of teaching at universities was not the result of any decline in the condition of collections either at universities or elsewhere.

23. It was understood that for the future, training of systematists would be undertaken at postgraduate level.

Aid Budgets and the World Bank

24. The World Bank's Global Environment Facility had been in existence since February, and amounted to one billion SDRs (SDR = special drawing right, a unit of account based on a basket of currencies), or \$1.3 million. The World Bank managed GEF on behalf of UNDP and UNEP to foster projects relating to global warming, the pollution of international waters, and the protection of biological diversity. This was a potential source of funds, but it struck us that it would not be easy to obtain monies from it unless the United Kingdom scientific community was pro-active in involving itself in GEF affairs. Much depended on the efficacy with which their Science Advisory Board (the SDAP) ensured that projects involved national scientists and collections in devising the projects to be funded. Scientific witnesses thought that GEF had not been properly thought through, and required more scientific input. The United Kingdom contribution comes from the Treasury and not from the ODA. **The question arises whether the United Kingdom's contribution to GEF of £40 million would be covertly deducted from ODA's budget or not.**

25. The US Agency for International Development (AID) and NSF had recently joined together to fund research on biological diversity in AID's target nations. This is to run for 1991 and 1992 with a total commitment of \$7.2 million, of which \$2.5 million comes out of the AID budget. Under the Aid/NSF program, the research must be conducted within the target country. **The question arises whether this collaboration could serve as a model for some earmarking of ODA funds for biodiversity research.**

26. The example of INBio in Costa Rica was frequently held up as a model of how an appropriate scientific infrastructure could be established in developing countries.

Perceptions of United Kingdom systematics

27. There was universal agreement that the collections at NHM and Kew were uniquely important.

28. Curation of collections at the NHM was now thought to be patchy, partly as a result of the variable quality of the research which was conducted on the collections. Witnesses were not unsympathetic to the recent restructuring within the Museum, but they thought that it had been badly handled and had given the impression that systematics was being downgraded.

29. Some thought that the United Kingdom had dropped behind the US in molecular systematics, and certainly in computer applications.

Organisations visited

British Embassy
 Association of Systematics Collections
 Office of Technology Assessment
 Smithsonian Institution
 (Round Table including Representative of:
 US Museum of Natural History
 American Museum of Natural History
 Philadelphia Academy of Natural Science
 New York Botanic Garden)
 National Science Foundation
 US Agency for International Development
 World Bank
 US Department of Agriculture

APPENDIX 6

List of Acronyms

ABRC	Advisory Board for the Research Councils
ABRS	Australian Biological Resources Study
AFRC	Agriculture and Food Research Council
AID	Agency for International Development
AIDS	Auto Immune Deficiency Syndrome
AUT	Association of University Teachers
BRAHMS	Botanical Research and Herbarium Management System
CABI	CAB International
CAMR	Centre for Applied Microbiology and Research
CASE	Collaborative Award in Science and Engineering
CCBR	Coordinating Commission for Biological Recording
CDSC	Communicable Disease Surveillance Centre
CITES	Convention on International Trade in Endangered Species
CPHL	Central Public Health Laboratory
CSL	Central Science Laboratories
DES	Department of Education and Science
DH	Department of Health
DNA	Deoxyribonucleic Acid
DOE	Department of the Environment
DTI	Department of Trade and Industry
EC	European Community
FAO	Food and Agriculture Organisation
FY	Financial Year
GEF	Global Environment Facility
GPSIS	Global Plant Species Information System
ICI	Imperial Chemical Industry
IIBC	International Institute of Biological Control
IIE	International Institute of Entomology
IIP	International Institute of Parasitology
ILDIS	International Legume Database and Information Service
IMI	International Mycological Institute
IPMS	Institution of Professionals, Managers and Specialists
IT	Information Technology
IUBS	International Union of Biological Sciences
MAFF	Ministry of Agriculture, Fisheries and Food
MGC	Museums and Galleries Commission
MICIS	Microbial Culture Information Service
MRC	Medical Research Council
NCCPG	National Council for the Conservation of Plants and Gardens

NERC	Natural Environment Research Council
NHM	Natural History Museum
NMS	National Museums of Scotland
NMW	National Museum of Wales
NRI	Natural Resources Institute
OAL	Office of Arts and Libraries
ODA	Overseas Development Administration
PCFC	Polytechnics and Colleges Funding Council
PHLS	Public Health Laboratory Service
RBG	Royal Botanic Garden(s)
RHS	Royal Horticultural Society
RNA	Ribonucleic Acid
SEM	Scanning electron microscopy
SERC	Science and Engineering Research Council
SOAFD	Scottish Office Agriculture and Fisheries Department
SPP	Species Plantarum
STAP	Scientific and Technical Advisory Panel
TEM	Transmission electron microscopy
UFC	Universities Funding Council
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

APPENDIX 7

Glossary of some Scientific Terms

DNA sequencing: This translates some small part of the total genetic “blueprint” of an organism into the code of letters which symbolise the chemicals which make up their DNA. The resulting sequence will be characteristic of that particular species—just as a part of a page of Shakespeare would be recognisable as being from that source, and distinct from a page of Shaw, and both distinct from part (of the text) of *The Sun*. The analogy is not so far-fetched in that a written text, like the DNA in an individual’s chromosomes, is formed from an alphabet of 26 letters; the alphabet of DNA is written in only four “letters”. Closely related organisms will have long runs of common sequences in their DNA, reflecting a common source, just as two newspaper articles describing the same events would have many common words, and perhaps even phrases, but would differ in details.

Immunological affinity: Immunology involves taking material from a plant or animal, and injecting the proteins in it into a small mammal (mouse, rabbit) which then produces an *antibody* to it (so as to gain “immunity” to this foreign protein). This antibody can be extracted from the blood of the test animal, and this will latch on to, and coagulate, very specifically, only the protein which had stimulated its production. Other, closely related but distinct proteins will show some reaction with the antibody, but a weaker one. The immune system of mammals can thus produce a recognition text-kit for protein material from other living things, which can test the similarity between organisms in these immunological terms.

Molecular biology: The study of the material making up plants and animals at the level of the kinds and arrangements of the atoms which comprise their component *molecules*. Areas of particular interest in this subject are the molecules involved in holding the “genetic blueprint” (the DNA) and its derivatives (RNA) involved in translating the blueprint into protein, and especially enzymes involved in the development and eventual structure and behaviour of individual organisms. This particular focus of molecular biology is sometimes called molecular genetics.

Cladistic analysis: This is a way of using a wide range of characters shown by a group of organisms to try to deduce their evolutionary history, and so make a classification which accurately reflects this. It places emphasis on whether a given character shared by two organisms is peculiar to them alone (and so probably arose in their shared ancestor) or whether it is shared by many other organisms, and so tells us less about the relationship of these two alone. Cladistics sets out in an orderly way the facts upon which a classification has been arrived at. Computer programmes are available to derive cladistic arrangements of organisms (cladograms) from large bodies of data.

Biochemical screening: This involves extracting a wide range of chemicals from a plant or animal (perhaps volatile, scented substances or just carbohydrates or amino acids) so that a pattern of

common (shared) constituents can be built up between a group of organisms. This is one way of getting a measure of the biological similarity between organisms.

Image analysis: The computerised comparison of shapes, sizes and patterns, of value in comparing the degree of structural similarity between organisms.

Protein gel electrophoresis: This is a method of characterising a given protein—or of comparing two similar proteins from two individuals—with a view to elucidating the closeness of their relationship. It involves placing the protein in a column of jelly, and building up a gradient of electrical charge along it, so causing separation of the constituents of the protein.

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